GS EP COR 771

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GENERAL SPECIFICATION

CORROSION

GS EP COR 771

Thermal insulation (hot and dual services)

01	09/2015	General revision
00	09/2013	First issue (cancels and replaces GS EP PVV 771 and GS EP PVV 773)
Rev.	Date	Purpose of the revision

Owning entity: DSO/TEC	Managing entity: DSO/TEC/COR

Contents

1. Scope

This general specification defines the technical requirements of thermal insulation materials and application, for equipment and piping on offshore and onshore installations, for hot and dual services.

The following are excluded:

- Equipment and piping:
  - For cold service (GS EP COR 772)
  - Buried
  - Subject to acoustic protection.
- Instruments
- Subsea pipelines (GS EP SPS 008 & GS EP COR 226)
- Internal insulation prefabricated at plant (exhaust ducts, for example)
- Thermal insulation for building and industrial installations (GS EP CIV 406).

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the effective date of this document.

Reference	Title
ASTM C1104	Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation
ASTM C165	Standard Test Method for Measuring Compressive Properties of Thermal Insulations
ASTM C177	Standard test method for steady-state heat flux measurement and thermal transmission properties by means of the guarded-hot-plate apparatus
ASTM C203	Standard Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation
ASTM C240	Standard test methods of testing cellular glass insulation block
ASTM C303	Standard Test Method for Dimensions and Density of Preformed Block and Board-Type Thermal Insulation
ASTM C411	Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation
ASTM C518	Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

Reference	Title
ASTM C552	Standard specification for cellular glass thermal insulation
ASTM C612	Standard specification for mineral fiber block and board thermal insulation
ASTM C764	Standard specification for mineral fiber loose fill thermal insulation
ASTM C795	Standard specification for thermal insulation for use in contact with austenitic stainless steel
ASTM C871	Standard Test Methods for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions
ASTM D1475	Standard Test Method for Density of Liquid Coatings, Inks, and Related Products
ASTM D1640	Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings
ASTM D1644	Standard Test Methods for Non volatile Content of Varnishes
ASTM D2126	Standard Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging
ASTM D2369	Standard Test Method for Volatile Content of Coatings
ASTM D256	Standard Test Method for determining the izod pendulum impact resistance of plastics
ASTM D2583	Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor
ASTM D2697	Standard Test Method for Volume Non volatile Matter in Clear or Pigmented Coatings
ASTM D3039	Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials
ASTM D4541	Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
ASTM D648	Standard Test Method for deflection temperature of plastics under flexural load in the edgewise position
ASTM D695	Standard Test Method for compressive properties of rigid plastics
ASTM D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D93	Standard Test Method for flash point by Pensky Martens closed cup tester
ASTM E136	Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C
ASTM E228	Standard Test Method for Linear Thermal Expansion of Solid Materials With a Push-Rod Dilatometer

Reference	Title
ASTM E408	Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques
ASTM E84	Standard test method for surface burning characteristics of building materials
ASTM E903	Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres
ASTM E96	Standard Test Methods for Water Vapor Transmission of Materials
ASTM F1249	Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor
BS 2782-0	Methods of testing Plastics. Introduction
BS 476 (Parts 6; 7)	Fire tests on building materials and structures. Method of test to determine the classification of the surface spread of flame of products - Parts 6; 7
DIN 4102	Reaction to fire test - ignitability of building products
EN 1062	Paints and varnishes - Coating materials and coating systems for exterior masonry and concrete
EN 12087	Thermal insulating products for building applications - Determination of long term water absorption by immersion
EN 12089	Thermal insulating products for building applications - Determination of bending behaviour
EN 12667	Thermal performance of building materials and products - Determination of thermal resistance by means of guarded hot plate and heat flow meter methods - Products of high and medium thermal resistance
EN 13468	Thermal insulating products for building equipment and industrial installations - Determination of trace quantities of water soluble chloride, fluoride, silicate, and sodium ions and pH
EN 13471	Thermal insulating products for building equipment and industrial installations - Determination of the coefficient of thermal expansion
EN 13501-1	Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests
EN 14305	Thermal insulation products for building equipment and industrial installations - Factory made cellular glass products - Specification
EN 14706	Thermal insulating products for building equipment and industrial installations - Determination of maximum service temperature

Reference	Title
EN 1604	Thermal insulating products for building applications - Determination of dimensional stability under specified temperature and humidity conditions
EN 1606	Thermal insulating products for building applications - Determination of compressive creep
EN 1609	Thermal insulating products for building applications. Determination of short term water absorption by partial immersion.
EN 826	Thermal insulating products for building applications - Determination of compression behaviour
EN ISO 10456	Building materials and products - Hygrothermal properties - Tabulated design values and procedures for determining declared and design thermal values
EN ISO 13787	Thermal insulation products for building equipment and industrial installations - Determination of declared thermal conductivity
IMO 2010 FTP Code	International Code for the Application of Fire Test Procedures 2010
ISO 37	Rubber, vulcanized or thermoplastic - Determination of tensile stress-strain properties
ISO 527-3	Plastics. Determination of tensile properties - Part 3: Test conditions for films and sheets
ISO 7390	Building construction - Jointing products - Determination of resistance to flow of sealants
ISO 8339	Building construction - Sealants - Determination of tensile properties (Extension to break)
ISO 9000	ISO 9000 series of standards: ISO 9000:2005, ISO 9001:2008 and ISO 9004:2009
NF P92-501	Safety against fire - Building materials - Reaction to fire tests - Radiation test used for rigid materials, or for materials on rigid substrates (flooring and finishes) of all thicknesses, and for flexible materials thicker that 5 mm

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

Reference	Title
GS EP CIV 406	Thermal and acoustic insulation
GS EP COR 226	Materials for thermal insulation of pipeline, piping and subsea components
GS EP COR 350	External protection of offshore and coastal structures and equipment by painting
GS EP COR 355	External protection of piping and equipment by thermal spray coating
GS EP COR 772	Thermal insulation (cold service)
GS EP ICS 002	2D CAD Process Schematics
GS EP PVV 111	Piping design specification
GS EP PVV 119	Design and fabrication of metallic piping supports - Standard for piping supports
GS EP PVV 202	Standard drawings for accessories and equipment vessels
GS EP PVV 211	Design and fabrication of pressure vessels according to ASME VIII
GS EP PVV 212	Design and fabrication of pressure vessels according to BSI PD 5500
GS EP SPS 008	Thermal insulation of subsea stations

3. Insulation Classes

The specific insulation codes as provided below according to GS EP ICS 002 which is the controlling document for specification of insulation codes.

Class B: Protection against solar radiation

The purpose is to prevent temperature rise above the critical temperature of the fluids contained in equipment or piping (taking into account maximum local solar radiation). Cover, screen, or ceramic blends insulating composite coating are the preferred solutions.

Class D: Dual (Cold and hot insulation)

The purpose is to prevent surface condensation and to reduce heat losses for cyclic (Dual) service, operating normally under cold conditions, but with periods of operation at high temperatures (e.g. molecular sieve gas dehydration unit). The temperature range of application for cyclic service in this specification is -80°C to +280°C. If operating temperature exists outside this range, then the insulation requirement shall be assessed on an individual basis based on particular job specification.

Class E: Class H with Electrical heat tracing

Class H: Heat conservation

The purpose is to reduce heat losses according to values defined in the Particular Project Specification (W/m^2 on equipment and W/lm on piping).

Class I: frost protection

The purpose is to prevent freezing or ice formation within piping/vessels. No disruption of service when ambient temperatures fall below 0°C.

Class P: Personnel protection

Surfaces with operating temperature less than -10°C and above +70°C and accessible from walkways and normal working areas shall be provided with personnel protection to a height 2.1 m above and 0.8 m away from the walkway or working area.

Note: Thermal insulation materials shall not be used for personnel protection, only metallic guards or ceramic blend insulating composite coating shall be used.

Class R: Class H with Liquid heat tracing.

Class S: Class H with Steam heat tracing.

For Class A (Acoustic insulation), Class L (Cold and acoustic) and Class T (Hot and acoustic), refer to Particular Project Specification.

For Class C (Cold conservation) and Class K (Condensation prevention), refer to GS EP COR 772.

4. Fire resistance

Other requirements for fire performance in terms of heat generation, flame spread and smoke development may apply depending on the facilities being assessed and local fire regulations require to be specified e.g. BS 476-6, BS 476-7 may be specified for Northern Continental shelf or IMO 2010 FTP Code regulations for shipping or FPSO units.

Unless otherwise specified, materials shall, at least, meet the requirements of EN 13501-1, Class B-S2-D0.

5. General Design

5.1 General

All design shall allow for necessary room for insulation with protective jacketing and preformed boxes. Particular care shall be taken in piping design to ensure sufficiently long straight pipe runs around e.g. branches, nozzles, bends, valves, flanges and supports to enable proper installation of insulation.

5.2 Insulation supports

Vertical piping, vessel and equipment shall be supplied with insulation supports in accordance with the insulation fabrication design documentation as per specification GS EP PVV 211 and/or

GS EP PVV 212 (depending which is applicable). Supports are supplied and installed by the piping or vessel fabricator.

Standard drawings for insulation supports are given in GS EP PVV 202.

5.3 Piping supports

Piping supports shall be designed according to GS EP PVV 119 and to insulation type and thickness.

For operating temperature over 120°C, a special design shall be defined to reduce heat transmission from pipe through the shoe (insulating wedges).

Final design shall be approved by Company.

5.4 Insulation tightness collars

Circular metallic collars shall be welded on piping and equipment to warranty the complete water tightness of the insulation protective cladding at insulation end termination. Collars are supplied and installed by the piping or vessel fabricator.

5.5 Surface preparation

All surfaces shall be appropriately protected in accordance with GS EP COR 350 or GS EP COR 355.

5.6 Insulation type and thickness

Piping and equipment shall be insulated according to the insulation class, operating temperature and insulation thickness defined in the Particular Project Specification, P&ID, line lists, and data sheets or construction drawings.

5.7 Extent of insulation

Nameplates, stamping, code inspection plates, shall be outside of insulation. Supports and brackets shall be designed in accordance with insulation thickness.

Each pipe shall be insulated as a single unit. A minimum clearance of 50 mm shall be provided between the outer surface of the insulation and any obstruction such as structural steel, piping or other insulated line.

6. Materials

6.1 General

- All materials shall be selected in accordance with the requirements specified within this section and shall be new, undamaged and free from contamination.
- Medical, Safety and Product data sheets for all materials shall be approved by Company.
- Materials shall have the following general properties:
  - Full agreement certificates
  - Completely free from asbestos

- Material shall not cause any harm or known hazard to health during application while in use, or on removal
- Chemically neutral with pH preferably between 7 and 8 in wet conditions
- Water soluble chloride and fluoride as low as possible
- Non-combustible. Cladding materials at least self-extinguishing
- Not corrosive to metal surfaces and compatible with coating system applied
- Impervious to water and water vapour, and chemically inert
- Odourless at normal operating temperature.

- Materials shall conform to the requirements of Material Specifications (Appendix 2).

6.2 Insulating materials

6.2.1 Cellular Glass (CG)

Cellular glass shall conform to the requirements of Material Data Sheet N°001.

Factory pre-fabricated and pre-coated pieces shall be used, except for special items or coating not in the Manufacturer fabrication list. These items shall be insulated with pieces cut from pipe sections or segment and perfectly fitted on site.

- Pipes sections or radiused and bevelled segments for straight parts.
- Two pieces (or more, according to size) preformed elbows, tees and reducers.
- Radiused and bevelled segments for equipment shells.
- Spherical or elliptical segments for vessel head and bottoms.
- Trapezoidal segments for cones.
- Prefabricated flange and valve boxes.

6.2.2 Micro-porous insulation (MPI)

Micro-porous insulation shall be based on pyrogenic silica with a mineral oxyde opacifier and E-glass filament reinforcement.

Micro-porous insulation shall conform to the requirements of Material Data Sheet N°004 or 005.

6.2.3 Ceramic blend insulating composite coating

Ceramic blend insulating composite coating shall be a blend of ceramic and fillers in a heat stable acrylic binder system.

Ceramic blend insulating composite coating shall conform to the requirements of Material Data Sheet N°006.

6.2.4 Mineral wool for expansion joint

Mineral wool shall be used only for expansion joints. It shall be a resilient loose rock wool with water soluble chloride and fluoride as low as possible (less than 10 mg/kg).

Mineral wool shall conform to the requirements of Material Data Sheet N°002.

6.3 Protective cladding

6.3.1 GRP laminated sheet (GRP)

The glass reinforced plastic shall be an UV curing laminated sheet or pre-cured cladding and moulded accessories.

The minimum thickness of GRP shall be 2 mm ± 0.2 mm.

The preferred method shall be the application of pre-cured pipe sections and moulded pieces for fittings as elbows, tees, reducers, end caps and vessel heads.

The GRP laminated sheet shall conform to the requirements of Material Data Sheet N°011 or 012.

6.3.2 Stainless Steel sheet

The stainless steel sheet used for insulation termination shall be AISI type 316L, 2B finish.

The minimum thickness shall be 0.50 mm.

6.3.3 Stainless steel welded mesh

The stainless steel welded mesh shall be AISI type 316L.

Ø 1 mm wire, 30 x 30 mm mesh.

6.3.4 Miscellaneous

All appurtenances and fixing shall be in AISI type 316L.

6.3.5 Coating mastic

Coating mastic shall be a tough, flexible and fire resistive elastomeric finish.

Coating mastic shall conform to the requirements of Material Data Sheet N°107.

6.3.6 High temperature collars for insulation termination (alternate)

The high temperature collars for insulation termination of the alternate solution shall be fabricated from panels of high temperature Roving of fiber glass and epoxy resin laminate, in two halves assembled by 316L stainless steel screws.

High temperature Roving of fiber glass and epoxy resin laminate shall conform to the requirements of Material Data Sheet N°115.

6.4 Insulation securement

6.4.1 Self-adhesive bands

Self-adhesive bands shall be a tape reinforced with continuous glass fibres in the longitudinal direction along with a polypropylene backing (glass reinforced filament tape).

The self-adhesive bands shall conform to the requirements of Material Data Sheet N°109.

6.4.2 Stainless steel bands and seals

Stainless steel bands and seals shall be AISI type 316L, 0.5 mm thick, 13, 19 or 25 mm width.

6.5 Anti-abrasive coating, sealant and adhesive

6.5.1 Anti-abrasive coating for cellular glass

Anti-abrasive coating shall be factory applied and used to prevent damage to cellular glass and painting.

The Anti-abrasive coatings shall conform to the requirements of Material Data Sheet N°101.

6.5.2 Reinforcement coating

Reinforcement coating shall be a combination of a two-component inorganic mortar and glass cloth reinforcement.

Reinforcement coating shall conform to the requirements of Material Data Sheet N°103.

6.5.3 Bonding adhesive

The bonding adhesive shall be a two components high strength thermosetting adhesive, remaining flexible after curing.

The bonding adhesive shall conform to the requirements of Material Data Sheet N°105.

6.5.4 Joint sealant

The joint sealant shall be a non hardening butyl based sealer.

The joint sealant shall conform to the requirements of Material Data Sheet N°104.

6.5.5 High temperature joint sealant

Heat resistant silicone sealant shall be a one-component silicone, elastomeric acetic sealant.

Heat resistant silicone sealant shall conform to the requirements of Material Data Sheet N°113.

6.5.6 GRP Adhesive

The GRP adhesive used to bond together GRP pre-moulded pieces shall be selected in accordance with GRP manufacturer instructions.

The GRP adhesive shall conform to the requirements of Material Data Sheet N°013 or 014.

6.5.7 Reinforcing fabric

Reinforcing fabric shall be a polyester open mesh fabric.

The reinforcing fabric shall conform to the requirements of Material Data Sheet N°112.

6.5.8 Aluminium-butyl Membrane

The aluminium-butyl membrane shall be an elastomeric modified butyl rubber, pressure sensitive adhesive laminated with an aluminium/polyester/aluminium laminate foil.

The aluminium-butyl membrane shall conform to the requirements of Material Data Sheet N°108.

6.5.9 Butyl rubber sheet

The cover over the outer insulation layer contraction joint shall be a poly-isobutylene sheet (butyl rubber), 1 mm thick x 180 to 200 mm wide.

The butyl rubber sheet shall conform to the requirements of Material Data Sheet N°110.

6.5.10 Flexible insulating blankets

Flexible insulating blankets shall be custom fabricated using a quilted construction of mineral wool mattress positioned between two fibreglass cloths. Fibreglass cloth shall be 0.45 mm thick minimum (>500 g/m²) and waterproof coated. Fibreglass cloth and insulation thickness shall be selected in accordance with the operating temperature.

The flexible insulating blankets shall conform to the requirements of Material Data Sheet N°116.

Materials and design shall be approved by Company.

7. General conditions for execution of works

7.1 Qualification requirements

- Operators, foremen and supervisor shall be individually certified by an approved organization or by the product's Manufacturer through the Applicator's training system.
- Operators shall be individually qualified to tradesman level as "insulation applicator" or "GRP applicator" and shall be familiar with the application of cellular glass and GRP.
- A register of qualified operators shall be documented (with photographic record). No untrained or unsupervised personnel shall be used for insulation application.
- Supervisors and Foremen shall be qualified to tradesman level and shall have documented minimum 3 years experience with insulation work described in this General Specification.
- QC or personnel carrying out inspection or verification shall be qualified by the products material suppliers, shall be familiar with the requirements in this General Specification, and shall be accepted as inspector by the Company.

7.2 Health, Safety and Environment

The Contractor shall take cognizance of the contents of the products safety data sheet and take appropriate preventive measures and precautions to save personnel from injury, intoxication and illness, in accordance with the project HSE plan.

The Contractor shall organize the management of waste in accordance with the project HSE plan and the Rules in force.

Personnel shall have a relevant knowledge of health and safety hazard, use of individual protection equipment, insulation systems surface requirements, and how to avoid corrosion under insulation.

7.3 Material supply, handling and storage

- All materials shall be supplied in accordance with the material specifications of Appendix 2, with their Conformity Certificate.

- Materials shall be properly packed, handled, transported and stored in accordance with the Manufacturer's instructions.
- The materials shall remain in the original packaging, identified with manufacturer name, product name, type, grade, density, thickness and dimensions. They shall be stored in dry areas, sheltered from water and sun, and not in direct contact with the ground.
- Adhesives, coating mastics and sealants shall remain in the original packaging, identified with manufacturer name, product name, type, batch number and expiry date. According to Manufacturer instructions (minimum and maximum storage temperature), storage in air-conditioned areas must be required.
- **Factory or shop prefabricated elements shall be properly packaged by the manufacturer in order to allow offshore transportation without damage:** cardbox shall be of strong and reinforced type, each element shall be individually wrapped and voids shall be filled with air buffers. Packages shall be properly sealed and identified with manufacturer name, product name, type, grade, density, thickness, dimensions and Project name. They shall be carefully stored and handled to prevent any damage or deformation.

7.4 Samples

Sample from each batch can be taken by the Company for conformance checking.

7.5 Preliminary conditions

Application Procedure and Inspection and Test Plan for work execution shall have been approved by Company or his representative.

The Applicator shall not commence any insulation works until a release report has been officially issued, authorising insulation application.

Piping and equipment shall have all welding completed and shall have been hydrostatically or pneumatically tested.

The thermal insulation supports and circular collars shall have been installed according to the insulation fabrication design documentation as per specification GS EP PVV 111, GS EP PVV 211 and/or GS EP PVV 212 (depending which is applicable).

Standard drawings for insulation supports are given in GS EP PVV 202.

The surfaces shall have been appropriately protected in accordance with GS EP COR 350 or GS EP COR 355 for carbon steels and stainless steels.

All tracer fastenings shall have been suitably installed, and the systems shall have been tried out (or tested in the case of electrical trace heating).

The Contractor shall advise the Company or its representative of any remedial work that may be required, in good time prior to commencement of insulation.

7.6 Pre-insulation

Manual or mechanical workshop pre-insulation on over-coated piping spool shall be recommended whenever possible.

7.7 Execution conditions

The Applicator shall obtain technical assistance from the Manufacturers.

Surfaces to be insulated shall be free of all oil, grease, loose scale and foreign matter, and shall be dry.

Insulation shall only be fitted if the substrate temperature is at least 3°C above the dew point.

No work shall be carried out during period of rain or in a damp environment, except under shelter and in a controlled atmosphere.

Application of the protective jacketing shall be done immediately after the installation of the insulation. Insulation awaiting protective cladding shall be provided with effective temporary weather and UV protection as polyethylene sheeting or tarpaulin. Insulation that has become wet shall be removed and replaced with dry material.

The use of broken pieces of insulation for the filling of gaps or voids caused by incorrect fitting is not permitted. Where such gaps or voids arise, the insulation shall be removed and refitted correctly.

8. Application

8.1 Insulation classes and systems

8.1.1 Class H

System 01: ambient to 120°C: CG (single or double layer) + GRP

System 02: 121 to 430°C: CG (single or double layer) + GRP

System 03: 431 to 800°C: Micro-porous + CG (double layer) + GRP

8.1.2 Class P

System 04: 70 to 150°C: Ceramic blend insulating composite coating (preferred system)

System 05: 70 to 150°C: Stainless Steel welded mesh

System 02: 151 to 430°C: CG (single or double layer) + GRP

System 03: 431 to 800°C: Micro-porous + CG (double layer) + GRP

8.1.3 Class I

Refer to class H

8.1.4 Classes E, R and S

Refer to class H

8.1.5 Class D

System 06: -80°C to +280°C: CG (double layer) + GRP

8.1.6 Class B

Solar radiation shall be defined in Particular Project Specification

8.1.7 Class A, L and T

Classes defined in accordance with the Particular Project Specification.

8.2 Application Procedure

Insulating material and protective jacketing shall be applied according to an approved Application Procedure, prepared by the Contractor according to the present specification and Manufacturer application procedures.

8.3 Cellular Glass

8.3.1 General

Pipe sections and segments shall be shaped to fit properly around the pipes, fittings, shells and heads.

Insulation thicknesses up to 70 mm could be applied as single layer.

In order to get rigid insulation system, longitudinal joints shall be staggered with an offset at least equal to 150 mm.

When insulation is applied in two layers or more, the sections or segments shall be staggered both radially and axially from the previous layer to the next one. Pipe sections shall be offset by 90° in successive layers and segments with an offset equivalent to half the segment width.

Application shall start by the installation of fittings insulation.

Pipe sections, segments and prefabricated pieces shall be tightly butted together and shall not be bonded to the substrate.

Gaps or open joints resulting from damaged material or poor fit are not permitted (maximum gap less than 1.5 mm).

8.3.2 Anti-abrasive coating

The anti-abrasive coating shall be factory applied onto the inner side of the cellular glass elements which will be in contact with the substrate.

The anti-abrasive coating shall be selected according to the operating temperature and Insulation System.

8.3.3 Reinforcement coating

For operating temperature over 120°C, and cellular glass applied in one or several layers, the inner surface of the first layer of cellular glass, in contact with the substrate or the micro-porous insulation, shall receive a coat of reinforcement coating mastic, factory applied.

8.3.4 Bonding adhesive

For operating temperature up to 120°C, adhesive may be used for full bonding of cellular glass to particular part of equipment or piping in order to facilitate insulation application (bottom head for example).

8.3.5 Joint sealing

For single layer application, all longitudinal and circumferential CG joints shall be sealed with joint sealant.

For a multi-layer application, the first or initial layers shall be applied dry. Only longitudinal and circumferential CG joints of the uppermost layer shall be sealed with joint sealant.

Joint sealants:

- For operating temperature ≤ 120°C: Material Data Sheet N°104
- For operating temperature > 120°C: Material Data Sheet N°113.

Joint sealant shall be preferably gun extruded, Ø 7 mm minimum bead, continuously without gap, at outermost side of the joint height, with continuity from longitudinal joints to circumferential joints. Any excess of sealant squeezed out of the joint shall be cleaned up by a careful smoothing.

8.3.6 Securement

Cellular glass pipe sections, segments and fittings shall be secured with filament tape with a 50% overlap of the tape per wrap.

Minimum wide of filament tape according to diameter over insulation:

- OD up to 500 mm: 19 mm
- 500 mm < OD ≤ 1000 mm: 25 mm
- OD > 1000 mm: 50 mm.

For double layer application, the uppermost layer shall be secured with filament tape as above. If the outside temperature of the first layer exceeds 130°C, first layer of insulation shall be secured with 316L stainless steel band and wing type seals:

- OD up to 500 mm: 13 x 0.5 mm
- OD > 1000 mm: 19 x 0.5 mm.

Each layer of insulation shall be secured independently every 300 mm, with a minimum of two bands for each section, segment or piece. The tension shall be such that the insulation is not damaged.

Cellular glass segments on bottom head and bottom under skirt shall be secured with stainless steel band, tightened from inside skirt supporting ring or from shell banding, on at least every 300 mm.

8.3.7 Lamination layer

An aluminium-butyl membrane shall be required on the uppermost CG layer, before the application of GRP cladding, in order to allow differential movements between CG and GRP and to avoid any cracks or tension into the GRP.

The aluminium-butyl membrane should be factory applied, particularly on elbows, tees, reducers and bottom heads.

8.3.8 Termination, penetration and protrusion

The cellular glass insulation at terminations and around penetrations and protrusions shall be treated so that water cannot penetrate into the insulation system. Joint sealer shall be selected according to operating temperature.

8.3.9 Expansion joints

In order to allow for differential linear expansion between metal and cellular glass, insulation on horizontal pipe shall be provided with expansion joints.

For carbon steel pipes:

- Operating temperature up to 175°C: not necessary
- Operating temperature from 175°C to 430°C: expansion joint every 5 m.

For stainless steel pipes:

- Operating temperature up to 130°C: not necessary
- Operating temperature > 130°C: expansion joint every 5 m.

An expansion joint shall consist of a 25 mm annular space in the insulation filled with mineral wool compressed 50 to 75 percent during installation. These joints shall be provided at each layer.

On vertical piping, at minimum one expansion joint shall be provided.

When insulation support rings are used on vertical piping and equipment, expansion joint shall be placed directly beneath each support ring.

8.3.10 Steam tracing

Cellular glass pipe sections or slabs shall be applied in two or more layers.

The thickness of the first layer shall equal or exceed slightly the tracer diameter.

Pipe sections or slabs of the first layer shall be cut and placed on both sides of the tracer or between the tracers if there are several tracers.

The same shall apply for fittings and steam traced equipments.

8.3.11 Electrical tracing

Pipe sections or slabs in contact with the pipe shall be grooved longitudinally in order to insert the cable.

Pipe sections or slabs shall be oversized for coiled spiral cables.

The penetrations of electrical tracing shall be positioned away from the prevailing weather and between the 4 o'clock and 8 o'clock positions on horizontal pipe.

8.4 Micro-porous insulation

8.4.1 General

Micro-porous insulation shall be used as a first layer when operating temperature exceeds 430°C (maximum operating temperature for cellular glass).

The thickness of micro-porous insulation shall be calculated to insure an inter-face temperature less than 430°C between micro-porous and cellular glass insulation.

Pipe sections, segments or mattresses shall be shaped to fit properly around the pipes, fittings, shells and heads.

Longitudinal joints shall be staggered for single layer application with an offset at least equal to 150 mm.

When insulation is applied in two layers or more, the sections, segments or mattresses shall be staggered both radially and axially from the previous layer to the next one, with an offset at least equal to the insulation thickness.

Pipe sections, segments or mattresses shall be tightly butted together.

Gaps or open joints resulting from damaged material or poor fit are not permitted.

8.4.2 Shape

The shape shall be selected according to the required minimum thickness and the pipe or equipment diameter.

- Lightweight flexible mattress, 5 or 10 mm thick, applied in one or several layers
- Moulded pipe sections or segments, 25 mm thick up to Ø 711 mm, applied in one or several layers.

8.4.3 Securement

Each layer of insulation shall be secured independently every 300 mm, with a minimum of two bands for each section, segment or piece. The tension of the retaining straps shall be such that the insulation is not damaged.

- Diameter over insulation up to 500 mm: 13 x 0.5 mm stainless steel band and seals
- Diameter over insulation 501 mm and over: 19 x 0.5 mm stainless steel band and seals.

8.5 Insulation supports

Piping and equipment insulation supports shall be supplied and installed by the piping or vessel fabricator (refer to paragraph 5.2).

8.6 Ceramic blend insulating composite coating

Ceramic blend insulating composite coating shall be applied in accordance with Manufacturer instructions and specification GS EP COR 350 or GS EP COR 355. Surface preparation shall be carried out in accordance with specification GS EP COR 350 or GS EP COR 355.

The thickness to be applied shall be selected in the Particular Project Specification according to the operating temperature in order to achieve the required surface temperature.

The number of coats shall be defined in accordance with the required final thickness and Manufacturer application instructions.

8.7 Stainless steel welded mesh

Stainless steel welded mesh shall be wrapped around spacers and secured by 19 x 0.5 mm stainless steel banding and seals.

Spacers shall be placed every 450 mm.

Spacers shall consist of bolted rings placed at 50 to 100 mm from the pipe by welded or riveted distance pieces. Distance pieces shall be placed every 200 mm, with 4 pieces minimum for pipe diameter up to 168 mm.

Bolted rings and distance pieces shall be pre-fabricated from 30 x 3 mm, 316L stainless steel flat bar or 25 x 1 mm stainless steel bands.

8.8 Protective cladding - Glass Reinforced Polyester (GRP)

8.8.1 General

The preferred method shall be the application of pre-cured pipe sections and moulded pieces for fittings as elbows, tees, reducers, end caps and vessel heads.

Pre-cured pipe sections and moulded pieces shall be supplied ex-factory or prefabricated in an onshore site workshop.

UV curing GRP shall only be applied on site when prefabricated pieces cannot be used.

The GRP cladding shall be applied in accordance with the Manufacturer instructions by trained and experienced personnel, certified by the Manufacturer (paragraph 7.1).

The GRP cladding shall be fully watertight.

8.8.2 Overlapping and bonding

Longitudinal joints shall be staggered.

Longitudinal and circumferential joints shall be positioned to shed water, and arranged with a minimum overlap of 30 mm up to OD 300 mm and 50 mm for higher OD, for straight parts.

For moulded fittings, the minimum overlapping shall be:

- OD ≤ 199: 15 mm
- 200 ≤ OD ≤ 299: 25 mm
- 300 ≤ OD ≤ 399: 35 mm
- OD ≥ 400: 45 mm.

Overlap shall be properly prepared and bonded together with recommended adhesive. The quantity of adhesive shall be sufficient to ensure perfect tightness. The excess of adhesive extruded during tightening shall be cleaned out by a careful smoothing.

During curing time of GRP adhesive, overlaps shall be firmly strapped with appropriate devices.

8.8.3 Vessel and equipment

Appropriate GRP grade and application method shall be defined or agreed by the GRP Manufacturer, according to specific data of each vessel and equipment.

According to the vessel design and size, the GRP cladding shall be reinforced by 316L stainless steel 19 x 0.5 mm supporting bands, equally spaced, and incorporated in the cladding by a bonded GRP backing strip.

8.8.4 Terminations, penetration and protrusion

At terminations and around penetrations and protrusions, the GRP cladding shall be treated so that water cannot penetrate into the insulation system.

For operating temperature up to 135°C, pre-moulded GRP end cap shall be bonded onto the pipe or steel protrusion.

For operating temperature exceeding 135°C, specific close-fitting metal collars shall be fabricated in 316 SS sheet. These shall be arranged to shed water, perfectly fitted and sealed with appropriate high temperature sealant.

Alternatively, high temperature collars fabricated in two halves from panels of high temperature Roving of fiber glass and epoxy resin laminate, and assembled by 316L stainless steel screws, may be used.

8.8.5 Expansion joints

In order to allow for differential linear expansion between metal, cellular glass and cladding, GRP cladding shall be provided with expansion joints.

Expansion joints shall be placed closely to the insulation expansion joints, if any.

These shall be placed, prepared and installed in accordance with Manufacturer instructions.

8.9 Coating mastic weatherproofing

For particular application, bottom under skirt for example, coating mastic shall be applied as weatherproofing. Application of coating shall be done immediately after the installation of the insulation.

The weatherproofing shall be applied in strict accordance with the Supplier's application instructions and shall comprise at least two layers of coating mastic, reinforced with a layer of reinforcing fabric.

8.10 Valves, flanges and removable parts

For reasons of leak detection and prevention of water ingress, flanges, valves and accessories shall not normally be insulated.

Adjacent Insulation shall allow sufficient clearance to insure that the valves shall remain operable and to facilitate maintenance operations.

At flanged joints, insulation shall be stopped at sufficient distance to allow the removal of studs without damaging adjacent insulation. The clearance, at each side of the flanged joint, shall equal at least the stud/bolt length plus 25 mm. See Sketch N°201, 203, 205 and 206.

However, when specified for process reasons, insulation of valves, flanges and removable parts shall be provided as follow:

8.10.1 Watertight insulation

Insulation for valves, flanges and removable parts shall be equal in thickness and type to that applied on adjacent pipe or equipment. The insulation shall be preformed or fabricated in single-matched halves to the maximum extent possible.

The insulation shall overlap the adjacent insulation by a minimum of 100 mm either side, and shall be applied with the same procedure.

The entire outer surface of insulation shall be sealed with vapour barrier membrane with 50 mm overlapping.

Shop fabricated GRP boxes or UV curing GRP shall be applied over the insulation.

Overlap shall be properly prepared and bonded together with recommended adhesive. The quantity of adhesive shall be sufficient to ensure perfect tightness. The excess of adhesive extruded during tightening shall be cleaned out by a careful smoothing.

During curing time of GRP adhesive, overlaps shall be firmly strapped with appropriate devices.

8.10.2 Removable covers

Removable covers shall be factory or shop prefabricated, according to design and dimensions defined on site, to encase the valve or flanged joint and to overlap the adjacent insulation.

The insulation shall be pre-fabricated in single-matched halves to the maximum extent possible. Insulation shall be bonded into shop fabricated GRP boxes. The different parts of the cover shall be fitted with 30 to 50 mm GRP overlapping and shall be secured with 316L stainless steel bands and quick release toggles.

The weight of any single piece shall not exceed 25 kg.

8.10.3 Drain hole

Drain holes shall be provided in the flange and valve removable boxes at the lowest point

8.10.4 Flexible insulating mattress

Flexible insulating mattresses shall be made of a minimum number of pieces and shall be designed to overlap adjacent insulation by a minimum of 100 mm on each side. Joints shall be arranged to avoid any water ingress. The weight of any single piece shall not exceed 25 kg.

Flexible insulating mattresses shall be fit tightly and held in place with Velcro (overlapping fixing shall preferred solution) or straps/belts with SS316L buckles.

8.11 Repairs

Execution defects shall be drawn to the Company attention through the Quality Assurance Plan and the method of repair shall be submitted to Company agreement.

8.11.1 Minor defect

Minor defects shall be treated according to Manufacturer instructions.

The final aspect of GRP cladding applied in situ may present some slight imperfection as wrinkle, ripple or emboss after curing. These shall not exceed 2 mm and should be abraded. Filler compound shall also be used for small repairs.

8.11.2 Major defect

The extent of the defect shall be subject to Company agreement.

The elements shall be fully removed and replaced by new materials after cleaning and checking of the substrate.

9. Tests, inspections and acceptance

9.1 Tests

Applicator shall check the following points, in accordance with the systems selected. The results of these checks shall be recorded in the control sheets.

- Compliance with specifications
- Compliance with fire testing specifications for combustible materials
- Conformity of thermal insulation supports and welded collars
- Condition of surfaces to which the thermal insulation is applied
- Climatic conditions of application
- Surface temperatures
- Quality of materials (compliance with specifications)
- Thickness and number of layers
- Quality of implementation (maximum gap between segments...)
- Effectiveness of fixings and clamping elements
- Quality of prefabrication of protective cladding components
- Compression of cladding on equipment and piping
- Fixing of cladding components to each other, overlaps
- Finishing
- Water tightness of insulation
- Quality and water tightness of the termination seals
- Quality and strength of removable boxes (assembly/dismantling).

9.2 Inspection

As part of the Quality Plan, an Inspection and Test Plan (ITP) including all points indicated in section 9.1 shall be prepared and submitted to Company who shall indicate the insulation operations to be reviewed or witnessed in the various phases of execution and inspection of the work.

9.3 Acceptance

9.3.1 Quality control

During acceptance testing by nominated party, a check shall be run to ensure that all the inspections listed in section 9 (Tests) have been carried out and that the results are satisfactory. Particularly emphasis shall be made with respect to inspection of jacket seals at penetrations and terminations and insulation overlaps to ensure natural water shedding is achieved.

9.3.2 Thermal efficiency

After start-up of the installation, the following checks may be carried out on Company request, in accordance with the Contract requirements:

- Surface temperature
- Heat losses.

Infrared cameras or other appropriate devices shall be used, according to the Company requirements (measurement locations and numbers, duration, etc.).

The results of the tests shall be recorded in a report.

A second check shall be carried out before the end of the warranty period.

Acceptance test operations shall be recorded in a report.

The Applicator shall guarantee that the insulation has been executed in strict compliance with this specification. Compliance shall be established through insulation thickness tables.

10. Technical documentation

10.1 Bid stage

Tenders shall include the following data:

- Contractor company profile
- Company quality system or manual (ISO 9000 or equal)
- Experience of similar projects and reference list
- List of subcontractors
- List of materials to be used with selected manufacturer and vendor
- List of deviations or exceptions
- Scope of work and method statement (outline)
- Key personnel and experiences
- Material storage and control policy
- HSE policy.

10.2 Prior to work commencement

Contractor shall supply the following documents and data before work commencement:

- Detailed Application Procedure based on the present specification, the project requirements and the Manufacturer application procedures, with detailed sketches and processing for all particular points
- Repair procedures
- A quality assurance plan (QAP), including Inspection and Test Plan (ITP) and in particular:
  - A nominal functional organisation chart
  - Qualified inspector supervision
  - The list of installation and inspection phases, and their associated procedures
  - List of installation and inspection equipment
  - Resources provided for protection against adverse climatic conditions (potential cocooning).
- List of materials with selected manufacturer and vendor, technical and safety data sheets, test certificates
- Detailed scope of work including a List of insulated equipment and piping with operating temperature, insulation type and thickness, detailed measurements and quantity.

10.3 At work completion

The technical documentation submitted by the Contractor on completion of the work shall include:

- Handover (or release) certificate duly signed
- Quality control plans with inspection forms or certificates
- Acceptance report
- Maintenance program
- Data book containing:
  - Certificates of conformity of materials
  - Certificates of manufacture of the thermal insulation materials
  - Certificates connected with tests and inspections by approved laboratories
  - Certificates of fire performance as required by this specification
  - Application procedures with detailed execution standards
  - Miscellaneous inspection forms
  - Reports of tests and checks on thermal efficiency and effectiveness
  - Acceptance test report.

Appendix 1 Description of insulation systems

System 01: ambient to 120°C: CG (single layer) + GRP

System 02: 121 to 430°C: CG (single or multi layer) + GRP

System 03: 431 to 800°C: Micro-porous + CG (multi layer) + GRP

System 04: 70 to 150°C: Ceramic blend insulating composite coating

System 05: 70 to 150°C: Stainless Steel welded mesh

System 06: -80°C to +280°C: CG (multi layer) + GRP

Note: identification principle

- **Systems: from 01 to 06**
- **Insulating materials: from 001 to 006**
- **Cladding materials: from 011 to 014**
- **Miscellaneous: from 100 to 113**
- **Principle sketches: from 201 to 212**

Appendix 1

SYSTEM 01

AMBIENT to 120°C

COMPONENT	DESCRIPTION	REF	REQUIREMENTS	COMMENTS
INSULATION	Single layer of cellular glass	001	Inner face coated with LTAA anti-abrasive coating N°101/102	Anti-abrasive coating shall be factory applied
	Pipe sections or segments		Pipe and equipment shell	
	Preformed pieces		Elbow, tee, cone, head…	
INSULATION JOINT SEALING	Joint sealant	104	All longitudinal and circumferential cellular glass joints	Gun extruded and applied continuously at 2/3 of insulation thickness
BONDING ADHESIVE	Two components high strength thermosetting adhesive	105	For insulation full bonding when required for particular application	I.E. Bottom head of equipment
INSULATION SECUREMENT	Filament tape	109	OD up to 500 mm: 19 mm wide 500 < OD ≤ 1000 mm: 25 mm wide OD > 1000 mm: 50 mm wide	Placed on 300 mm centers, two bands minimum per section or piece
FINISHING COATING	Alu-butyl membrane	108	Applied on external face of cellular glass	Should be factory applied, particularly for pre-fabricated fittings
EXPANSION JOINTS	Mineral wool	002	See paragraph 8.3.9	
CLADDING	Glass Reinforced Polyester (GRP)	011/012	Pre-cured sections	For pipe and equipment shell
			Pre-cured moulded pieces	For fittings as elbows, tees, reducers, bottom heads, end caps…
			U.V. curing	For special pieces cladded on site
CLADDING SECUREMENT	GRP Adhesive	013/014	Bonding and sealing of overlapping	OD ≤ 300 mm: overlap 30 mm mini OD > 300 mm: overlap 50 mm mini
	316L Stainless Steel bands		19 x 0.5 mm with GRP backing strip	When required, on equipment
CLADDING SEALING	GRP End caps + GRP Adhesive	013/014	Moulded pieces and/or UV curing GRP applied on site	Bonded on pipe or steel protrusion

Appendix 1

SYSTEM 02

OPERATING TEMPERATURE: 121°C to 430°C

COMPONENT	DESCRIPTION	REF	REQUIREMENTS	COMMENTS
INSULATION	Single layer of cellular glass	001	Inner face coated with reinforcement coating N°103	Insulation thickness ≤ 70 mm
	Multi layer of cellular glass		Inner face of first layer coated with reinforcement coating N°103	Insulation thickness > 70 mm
	Pipe sections or segments		Pipe and equipment shell	Reinforcement coating shall be factory applied
	Preformed pieces		Elbow, tee, cone, head…	
INSULATION JOINT SEALING	High temperature Joint sealant	113	All longitudinal and circumferential cellular glass joints of the uppermost layer (For double layer application, the first layer is applied dry)	Gun extruded and applied continuously at 2/3 of insulation thickness
INSULATION SECUREMENT	Filament tape	109	OD up to 500 mm: 19 mm wide 500 < OD ≤ 1000 mm: 25 mm wide OD > 1000 mm: 50 mm wide	Placed on 300 mm centers, two bands minimum per section or piece of each layer
	316L Stainless Steel bands		OD up to 500 mm: 13 x 0.5 mm OD > 1000 mm: 19 x 0.5 mm	For first layer securement if the outside temperature exceed 130°C and when required, on equipment
FINISHING COATING	Alu-butyl membrane	108	Applied on external face of cellular glass	Should be factory applied, particularly for pre-fabricated fittings
EXPANSION JOINTS	Mineral wool	002	See paragraph 8.3.9	
CLADDING	Glass Reinforced Polyester (GRP)	011/012	Pre-cured sections	For pipe and equipment shell
			Pre-cured moulded pieces	For fittings as elbows, tees, reducers, bottom heads, end caps…
			U.V. curing	For special pieces cladded on site
CLADDING SECUREMENT	GRP Adhesive	013/014	Bonding and sealing of overlapping	OD ≤ 300 mm: overlap 30 mm mini OD > 300 mm: overlap 50 mm mini
	316L Stainless Steel bands		19 x 0.5 mm with GRP backing strip	When required, on equipment

Appendix 1

SYSTEM 02

OPERATING TEMPERATURE: 121°C to 430°C

COMPONENT	DESCRIPTION	REF	REQUIREMENTS	COMMENTS
CLADDING SEALING	GRP End caps + GRP Adhesive	013/014	Moulded pieces and/or UV curing GRP applied on site and bonded on pipe or steel protrusion	Maximum operating temperature up to 135°C
	316L Stainless steel end cap and collars		Pre-fabricated pieces applied on site	Operating temperature over 135°C
	High temperature mastic Sealant	113	Sealing of end cap and collars	

Appendix 1

SYSTEM 03

OPERATING TEMPERATURE: 431°C to 800°C

COMPONENT	DESCRIPTION	REF	REQUIREMENTS	COMMENTS
PRIMARY INSULATION	Micro-porous pipe section, segment or flexible mattress	004/005	According to primary insulation thickness and pipe or equipment size	Thickness shall be calculated to insure an inter-face temperature less than 430°C between micro-porous and cellular glass insulation
PRIMARY INSULATION SECUREMENT	316 L Stainless steel bands		OD ≤ 500: 13 x 0.5 mm OD > 500: 19 x 0.5 mm	placed on 300 mm centers, two bands minimum per section or piece of each layer
INSULATION	Multi layer of cellular glass	001	Inner face of first layer coated with reinforcement coating N°103	
	Pipe sections or segments		Pipe and equipment shell	Reinforcement coating shall be factory applied
	Preformed pieces		Elbow, tee, cone, head…	
INSULATION JOINT SEALING	High temperature Joint sealant	113	all longitudinal and circumferential cellular glass joints of the uppermost layer (For double layer application, the first layer is applied dry)	Gun extruded and applied continuously at 2/3 of insulation thickness
INSULATION SECUREMENT	Filament tape	109	OD up to 500 mm: 19 mm wide. 500 < OD ≤ 1000 mm: 25 mm wide OD > 1000 mm: 50 mm wide	placed on 300 mm centers, two bands minimum per section or piece of each layer
	316L Stainless Steel bands		OD up to 500 mm: 13 x 0.5 mm OD > 1000 mm: 19 x 0.5 mm	For first layer securement if the outside temperature exceed 130°C and when required, on equipment
FINISHING COATING	Alu-butyl membrane	108	Applied on external face of cellular glass	Should be factory applied, particularly for pre-fabricated fittings
CLADDING	Glass Reinforced Polyester (GRP)	011/012	Pre-cured sections	For pipe and equipment shell
			Pre-cured moulded pieces	For fittings as elbows, tees, reducers, bottom heads, end caps…
			U.V. curing	For special pieces cladded on site

Appendix 1

SYSTEM 03

OPERATING TEMPERATURE: 431°C to 800°C

COMPONENT	DESCRIPTION	REF	REQUIREMENTS	COMMENTS
CLADDING SECUREMENT	GRP Adhesive	013/014	Bonding and sealing of overlapping	OD ≤ 300 mm: overlap 30 mm mini OD > 300 mm: overlap 50 mm mini
	316L Stainless Steel bands		19 x 0.5 mm with GRP backing strip	When required, on equipment
CLADDING SEALING	316L Stainless steel end cap and collars		Pre-fabricated pieces applied on site	
	High temperature Mastic Sealant	113	Sealing of end cap and collars	Gun extruded

Appendix 1

SYSTEM 04

CLASS P: 70 to 150°C

COMPONENT	DESCRIPTION	REF	REQUIREMENTS	COMMENTS
SURFACE PREPARATION AND PRIMER			Application procedure shall be in accordance with GS EP COR 350 and GS EP COR 355	
CERAMIC BLEND INSULATING COMPOSITE	blend of ceramic and special fillers in a heat stable acrylic binder system	006	Thickness in accordance with operating temperature and Manufacturer recommendations	Application in accordance with Manufacturer procedure
TOP COATING	Finish coat as defined in GS EP COR 350 (cf. system P01)		In accordance with Manufacturer Procedure	If required

Appendix 1

SYSTEM 05

CLASS P: 70 to 150°C

COMPONENT	DESCRIPTION	REF	REQUIREMENTS	COMMENTS
SPACERS	316L Stainless steel bolted rings placed at 50 to 100 mm from the pipe		Pre-fabricated from 30 x 3 316L stainless steel flat bar or 25 x 1 stainless steel bands Distance pieces every 200 mm, 4 pieces minimum up to Ø 168 mm	Placed on 450 mm centers
METALLIC GUARD	316L Stainless steel welded mesh		Ø 1 mm wire, 30 x 30 mm mesh	Wrapped around spacers
METALLIC GUARD SECUREMENT	316L Stainless steel bands		19 x 0.5 mm	1 band per spacer

Appendix 1

SYSTEM 06

OPERATING TEMPERATURE: -80°C to 280°C (cyclic cold and hot)

COMPONENT	DESCRIPTION	REF	REQUIREMENTS	COMMENTS
INSULATION	Double layer of cellular glass	001	Inner face of first layer coated with reinforcement coating N°103	Insulation thickness ≥ 60 mm (2 x 30 mm) minimum
	Pipe sections or segments		Pipe and equipment shell	HT Anti-abrasive and reinforcement coating shall be factory applied
	Preformed pieces		Elbow, tee, cone, head…	
INSULATION JOINT SEALING	Joint sealant	104/113	All longitudinal and circumferential cellular glass joints of the uppermost layer **The first layer shall be applied dry**	Two Ø 7 mm beads gun extruded and applied continuously
INSULATION SECUREMENT	Filament tape	109	OD up to 500 mm: 19 mm wide. 500 < OD ≤ 1000 mm: 25 mm wide OD > 1000 mm: 50 mm wide	placed on 300 mm centers, two bands minimum per section or piece of each layer
	316L Stainless Steel bands		13 x 0.5 or 19 x 0.5 mm	When required, on equipment
EXPANSION JOINTS	Mineral wool	002	See paragraph 8.3.9	
FINISHING COATING	Alu-butyl membrane	108	Applied on external face of cellular glass	Should be factory applied, particularly for pre-fabricated fittings
CLADDING	Glass Reinforced Polyester (GRP)	011/012	Pre-cured sections	For pipe and equipment shell
			Pre-cured moulded pieces	For fittings as elbows, tees, reducers, bottom heads, end caps…
			U.V. curing	For special pieces cladded on site
CLADDING SECUREMENT	GRP Adhesive	013/014	Bonding and sealing of overlapping	OD ≤ 300 mm: overlap 30 mm mini OD > 300 mm: overlap 50 mm mini
	316L Stainless Steel bands		19 x 0.5 mm with GRP backing strip	When required, on equipment
CLADDING SEALING	GRP End caps + GRP Adhesive		Moulded pieces and/or UV curing GRP applied on site and bonded on pipe or steel protrusion	Maximum operating temperature up to 135°C
	316L Stainless steel end cap and collars	113	Pre-fabricated pieces applied on site and sealed with high temperature sealant	Operating temperature over 135°C

Appendix 2 Materials specifications

MATERIAL	FORM	DATA SHEET N°
Cellular Glass	Slabs, blocks, pipe sections, segments and preformed pieces for elbows, tees, reducers and bottom head	001
Mineral wool for expansion joints	Loose fill	002
Microporous insulation	Flexible rolls	004
Microporous insulation	Moulded pipe sections and segments	005
Ceramic blend insulating composite	Drum	006
Glass reinforced polyester (GRP) FTI systems	UV curing laminated sheet or in pre-cured pipe sections and moulded accessories as elbows, tees, reducers, end caps, valve and flanges boxes, etc.	011
Glass reinforced polyester (GRP) SolarTech systems	UV curing laminated sheet or in pre-cured pipe sections and moulded accessories as elbows, tees, reducers, end caps, valve and flanges boxes, etc.	012
Adhesive for GRP	Drum or cartridge	013
	Drum or cartridge	014
High temperature anti-abrasive	Powder	100
Low temperature anti-abrasive	Drum	101
	Drum	102
Insulation reinforcement coating	Factory applied	103
Insulation joint sealant	Drum	104
Insulation bonding adhesive	Drum	105
Coating mastic	Drum	107
Aluminium-Butyl membrane	Rolls	108
Self adhesive bands	Rolls	109
Butyl Rubber sheet	Rolls	110
Reinforcing fabric	Rolls	112
High temperature joint sealant	Cartridge	113
High temperature collars	Cylindrical collars in two halves assembled by 316L SS screws	115
Flexible insulating mattress	Flexible enclosure for valves and flanged joints	116
Stainless Steel	316 L Sheets, 0.5 mm thick	
Stainless Steel Bands and seals	316 L: 13, 19, 25 x 0.5 mm thick with "wing" type seals	
	316 L: 25 x 1 mm thick	
Stainless steel flat bar	316 L, 30 x 3 mm	
Stainless Steel welded mesh	316 L Ø 1 mm wire, 30 x 30 mm mesh	

Appendix 2

Material specifications N°001

EXPANDED CELLULAR GLASS		Form: slabs, blocks, pipe sections, segments and preformed pieces for elbows, tees, reducers and bottom head				
Properties	**Documents Reference**	**Min/max values**				**Remarks**
Product	ASTM C552 EN 14305	Expanded cellular glass without binder with homogeneous closed cell structure				
General specification	ASTM C240 EN 14305	FOAMGLAS® ONE or equivalent approved by Company				
Apparent density	ASTM C240 / ASTM C303 EN 1062	115 kg/m^3 ± 10%				
Service temperature limits	Prod data sheet	-265°C to +430°C				
Thermal conductivity	ASTM C240 ASTM C518, ASTM C177 Prod data sheet EN ISO 13787	W/mK				Tm °C = mean temperature
		Tm°C	Blocks/ slabs	Pipe sections/ elbows	Pipe segments/ others assembled pieces	
		- 120	0.025	0.027	0.028	
		- 80	0.029	0.031	0.033	
		- 40	0.034	0.037	0.038	
		0	0.040	0.043	0.045	
		+ 40	0.046	0.050	0.052	
		+ 100	0.057	0.062	0.064	
		+ 160	0.070	0.075	0.079	
		+ 220	0.085	0.091	0.095	
Response to flame	ASTM E84 / ASTM E136	FSI = 0; SDI = 0				See section 4.1
Reaction to fire	EN 13501-1	Euroclass A1				
Specific heat	EN ISO 10456	1000 J/kg.K				
Water vapour permeability	ASTM E96 EN ISO 10456	0.00 ng/Pa.s.m (0.00 perm.inch) μ = oo				
Water absorption	ASTM C240 EN 1609 EN 12087	None, apart from temporary surface retention				
Coefficient of linear expansion	ASTM E228 EN 13471	25 to 300°C: 9 x 10^{-6}/K^{-1} - 170 to 25°C: 6.6 x 10^{-6}/K^{-1}				
Dimensional stability	EN 1604 ASTM D2126	$Di_{l,b} \leq 0.5$; $\Delta\varepsilon_d \leq 1$				

Appendix 2

Material specifications N°001

EXPANDED CELLULAR GLASS		Form: slabs, blocks, pipe sections, segments and preformed pieces for elbows, tees, reducers and bottom head	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Compressive strength	ASTM C240 / ASTM C165 / ASTM C552	620 kPa	
	EN 826	CS > 600 kPa	
Compressive creep	EN 1606	CC (1.5/1/50) ≥ 225 kPa	
Flexural strength	ASTM C240 / ASTM C203	480 kPa	
	EN 12089	BS > 450 kPa	
Trace quantities of water soluble chloride	EN ISO 10456	CL ≤ 2 mg/kg	
Resistance to chemical agents	Prod data sheet	All common acids except Hydrofluoric acid and strongly Alkaline solutions	
	ASTM C871		

NOTE: If the temperature difference across the two sides of a single layer of cellular glass is more than l20K or if the speed of temperature rise is > 2K/min, cracking may occur as a result of thermal stresses. In such cases, multi-layer system shall be applied.

Appendix 2

Material specifications N°002

MINERAL WOOL FOR EXPANSION JOINTS		Form: loose fill (rolls)			
Properties	**Documents Reference**	**Min/max values or Requirements**			
Product	ASTM C764	Loose rock wool with diabase or basalt rock as principal raw materials			
Apparent density		According to the stuffing (60 to 100 kg/m^3)			
Service temperature limits	EN 14706	680°C			
	ASTM C411	750°C			
Thermal conductivity	ASTM C177 EN 12667	**Tm°C**	**W/mK max.**	**W/mK max.**	Tm °C = mean temperature
	Prod data sheet		60 kg/m^3	100 kg/m^3	
		100	0.043	0.050	
		150	0.053	0.058	
		200	0.062	0.068	
		250	0.071	0.076	
Water leachable chloride content	EN 13468	< 10 mg/kg AS quality for use over stainless steel			
	ASTM C795 / ASTM C871	< 10 mg/kg (ph value neutral to slightly alkaline)			
Shot content	.	None			
	ASTM C612				
Combustibility	EN 13501-1	Non combustible A1			
	ASTM E84	Flame spread inex: 0			
Water vapour absorption	ASTM C1104 Data sheet	0.02% volume			
Water absorption	EN 1609	≤ 10% volume			
		< 1 kg/m²			
Resistance to chemical agents	ASTM C871	Imputrescible			
	Prod data sheet				

Appendix 2

Material specifications N°004

FLEXIBLE MICROPOROUS INSULATION		Form: lightweight flexible roll, stitched through on a parallel grid pattern		
Properties	**Documents Reference**	**Min/max values or Requirements**		
Product	Prod data sheet	Microporous formulation based on pyrogenic silica with a mineral oxyde opacifier and E-glass filament reinforcement		
Dimensions	Prod data sheet	5 mm thick: 914 wide x 10.8 m long 10 mm thick: 914 wide x 8.4 m long		
Apparent density	Prod data sheet	260 ± 30 kg/m³		
Service temperature limits	Prod data sheet	1000°C		
Thermal conductivity	Prod data sheet	**Tm°C**	**W/mK max.**	Tm °C = mean temperature
		100	0.026	
		200	0.028	
		300	0.031	
		400	0.035	
Specific heat capacity	Prod data sheet	**Tm°C**	**J/kg.K**	Tm °C = mean temperature
		0	680	
		200	920	
		400	1000	
Combustibility	EN 13501-1	Non combustible A1		

NOTE: Microtherm SlimFlex or equivalent.

Appendix 2

Material specifications N°005

MOULDED MICROPOROUS INSULATION		Form: pipe sections and segments for piping		
Properties	**Documents Reference**	**Min/max values or Requirements**		
Product	Prod data sheet	Microporous formulation based on pyrogenic silica with a mineral oxyde opacifier and E-glass filament reinforcement		
Dimensions	Prod data sheet	25 mm thick x 500 mm long standard piping diameter from 34 to 711 mm		
Apparent density	Prod data sheet	320 to 350 kg/m³		
Service temperature limits	Prod data sheet	1000°C		
Thermal conductivity	Prod data sheet	**Tm°C**	**W/mK max.**	Tm °C = mean temperature
		100	0.0221	
		200	0.0222	
		300	0.0230	
		400	0.0244	
		500	0.0260	
		600	0.0281	
		800	0.0343	
Specific heat capacity	Prod data sheet	**Tm°C**	**J/kg.K**	Tm °C = mean temperature
		0	680	
		200	920	
		400	1000	
		600	1040	
		800	1080	
Compressive strength	ASTM C165	0.32 Mpa (10% deformation)		
Combustibility	EN 13501-1	Non combustible A1		

NOTE: Microtherm MPS or equivalent.

Appendix 2

Material specifications N°006

CERAMIC BLEND INSULATING composite coating		Form: drum	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product	Prod data sheet	blend of ceramic and fillers in a heat stable acrylic binder system	
Apparent density	Prod data sheet		
Solids (non-volatile)	ASTM D2697	90% by volume	
Thermal conductivity	ASTM C177	0.057 BTU/h.ft.°F	at 25°C and 4.32 mm (0.172")
Emissivity	ASTM E408	0.88	
Solar reflectivity	ASTM E903	86.20	
Thermal Transmittance	ASTM C177	3.98 BTU/h.ft².°F	at 25°C
Flame Spread	ASTM E84 (system 3300)	flame spread: 0	Smoke development: 0
Flash point	Prod data sheet	> + 93°C	
Service temperature limits	Prod data sheet	- 51 to + 176°C	
Coverage rate	Prod data sheet	1.6 to 1.8 m²/l	at 500 microns
Application temperatures	Prod data sheet	+ 10 to + 38°C	Product
		+ 10 to + 150°C	Substrate
		+ 10 to + 43°C	Ambient
Curing	Prod data sheet	at 50% HR for 500 microns	6 h at 15°C, 3 h at 24°C, 1.5 h at 32°C (dry to recoat with himself)
Colour	Prod data sheet	white	
Storage	Prod data sheet	+ 4 to + 43°C	24 months at 24°C - Keep from freezing

NOTE: CARBOTHERM 551 Carboline, DELTA T Mascoat, or equivalent.

Appendix 2

Material specifications N°011

GLASS REINFORCED POLYESTER (GRP)		Form: UV curing laminated sheet delivered in 0.6 to 1.0 m wide x 10 m long rolls or in pre-cured pipe sections and moulded accessories as elbows, tees, reducers, end caps, valve and flanges boxes, etc.	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		**F T I** glass reinforced plastic UV curing laminated sheet and pre-cured cladding and moulded accessories	
Construction		Isophthalic Polyester resin reinforced with shopped glass fibers and surfacing tissue	
Curing mechanism	Prod data sheet	Ultra Violet, natural or UV lamp (wave length 365 to 420 mm) at -15 to +70°C	
Apparent density	Prod data sheet	1.5 g/cm³	
Thickness	Prod data sheet	2 mm ± 0.2	
Tensile strength	ASTM D3039	71 Mpa	
Service temperature limit	Prod data sheet	90°C	Fibaclad VEFR: 135°C
Flexural strength	ASTM D790	> 130 Mpa	
Elongation at break	ASTM D3039	1.25%	
Compressive strength	ASTM D695	138 Mpa	
Impact resistance	ASTM D256	70 kJ/m²	
Hardness	ASTM D2583	> 60 Barcol	
Adhesion to steel	ASTM D4541	> 14 Mpa	
Permeability	ASTM E96	0.012 g/m².h.mmHg	
Colour	Prod data sheet	Off white or grey	
Heat distortion	ASTM D648	> 255°C	
Flame spread index	BS 476-7	Class 1	
Flammability	NF P92-501	M 1	
Flame spread index	ASTM E84	15/50	
Storage	Prod data sheet	dry, < 25°C	12 months in closed original packing as per manufacturer instructions

NOTE: FTI Fibaroll/Fibaclad - Refer to Manufacturer application procedure.

Appendix 2

Material specifications N°012

GLASS REINFORCED POLYESTER (GRP)		Form: UV curing laminated sheet delivered in 0.92 m wide x 10 m long rolls or in pre-cured pipe sections and moulded accessories as elbows, tees, reducers, end caps, valve and flanges boxes, etc.	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		**SOLARTECH** glass reinforced plastic UV curing laminated sheet and pre-cured cladding and moulded accessories	
Construction		High grade Isophthalic Polyester resins fillers and glass reinforcements	
Curing mechanism	Prod data sheet	Ultra Violet, natural or UV lamp	
Weight	Prod data sheet	1.5 g/cm³	
Thickness	Prod data sheet	2 mm ± 0.2	
Tensile strength	BS 2782-0	55 Mpa	
Service temperature limit	Prod data sheet	dry: 130°C	wet: 90°C
Flexural strength	ASTM D790	> 130 Mpa	
Elongation at break	BS 2782-0	> 3%	SolarClad / SolarTech
Compressive strength	ASTM D695	> 200 Mpa	SolarClad / SolarTech
Impact resistance	ASTM D256	> 60 kJ/m²	SolarClad / SolarTech
Hardness	ASTM D2583	> 60 Barcol	
Adhesion to steel	ASTM D4541	> 14 Mpa	
Permeability	ASTM E96	0.012 g/m².h.mmHg	
Colour	Prod data sheet	grey	
Heat distortion	ASTM D648	> 145°C	SolarClad / SolarTech
Flame spread index	BS 476-7	Class 1	
Storage	Prod data sheet	dry, < 25°C	12 months in closed original packing as per manufacturer instructions

NOTE: SolarTech SolarClad/ PE55 - Refer to Manufacturer application procedure.

Appendix 2

Material specifications N°013

ADHESIVE for Glass Reinforced Polyester		Form: drum or cartridge	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product	Prod data sheet	FibaBond 2K: two component adhesive based on silane modified polymers	
	Prod data sheet	FibaBond HT: two component alkoxy cure silicone	
Solvent	Prod data sheet	Free from solvents and isocyanates	
Apparent density	Prod data sheet	1.35 g/cm³	FibaBond 2K
	Prod data sheet	1.43 g/cm³	FibaBond HT
Tensile strength	ISO 37 (at 23°C)	3 Mpa	FibaBond 2K
	ISO 527-3	1.28 Mpa	FibaBond HT
Service temperature limit	Prod data sheet	-40 to + 100°C	(short exposure: +120°C - 1h max.) FibaBond 2K
	Prod data sheet	-40 to + 180°C	(short exposure: + 220°C - 1h max.) FibaBond HT
Cure temperature	Prod data sheet	- 5 to + 50°C	
Curing time	Prod data sheet	1.5 to 3 hours	(90% of cure in 24 hours) FibaBond 2K
	Prod data sheet	skin over time: 12 min.	(fixture time: 12 hours) - FibaBond HT
Elongation at break	ISO 37 (200 mm/min)	150%	FibaBond 2K
	ISO 527-3	230%	FibaBond HT
Mixing ratio	Prod data sheet	1: 1	FibaBond 2K
	Prod data sheet	2: 1	FibaBond HT
Pot life	Prod data sheet	20 minutes @ 23°C	FibaBond 2K
	Prod data sheet	5 minutes @ 25°C	FibaBond HT
Colour	Prod data sheet	white	FibaBond 2K
	Prod data sheet	black	FibaBond HT
Storage	Prod data sheet	10 to 25°C	9 months in original unopened package - FibaBond 2K
	Prod data sheet	8 to 21°C	12 months in original unopened package - FibaBond HT

NOTE: FTI Fibabond - Refer to Manufacturer application procedure.

Appendix 2

Material specifications N°014

ADHESIVE for Glass Reinforced Polyester		Form: drum or cartridge	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product	Prod data sheet	elastomeric polymer adhesive based on Silyl modified polymer	
Apparent density	Prod data sheet	1.4 g/cm³	SolarBond
Tensile strength	ISO 37 (100%)	± 1.7 Mpa	
Tensile strength at break	ISO 37	± 2.6 Mpa	
Elongation at break	ISO 37	250%	
Service temperature limit	Prod data sheet	-40 to + 120°C	(short exposure: +180°C - 1/2 h max.)
Application temperature	Prod data sheet	+ 5 to + 35°C	
Mixing ratio	Prod data sheet	one component	
Open time	Prod data sheet	15 minutes @ 20°C	
Colour	Prod data sheet	white, grey	other colours available
Storage	Prod data sheet	5 to 30°C	12 months in original unopened container (cartridge: 18 months)

NOTE: SolarBond from SolaTech - Refer to Manufacturer application procedure.

Appendix 2

Material specifications N°100

HIGH TEMPERATURE ANTI-ABRASIVE COATING		**Form:** powder delivered in polyethylene lined paper bags	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		Gypsum cement with inert fillers	
Apparent density	Prod data sheet	0.70 kg/dm^3 1.0 kg/dm^3	Powder Applied bore coating
Service temperature limits	Prod data sheet	- 180°C to + 350°C	
Application temperature	Prod data sheet	+ 5 to + 40°C	
Working time at +25°C	Prod data sheet	about 30 minutes	
Vicat setting time at +20°C	Prod data sheet	between 60 to 120 minutes	
Complete drying (dry weather)	Prod data sheet	about 24 hours	
Water vapour diffusion resistance	Prod data sheet	$\mu < 30$	Should not be used as vapour barrier
Colour	Prod data sheet	dark grey	
Fire resistance	Prod data sheet	non-combustible	
Mixing ratio	Prod data sheet	water = 6.5 to 7.5 kg	for 10 kg powder

NOTE: Pittsburgh Corning HTAA or equivalent.

Appendix 2

Material specifications N°101

LOW TEMPERATURE ANTI-ABRASIVE COATING		Form: drum	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		one-component acrylic based coating, for factory application	
Apparent density	Prod data sheet	0.9 kg/dm3	
Solids (non-volatile)	Prod data sheet	50% by weight	
Service temperature limits	Prod data sheet	- 180°C to + 120°C	
Application temperature	Prod data sheet	+ 5°C minimum	
Drying	Prod data sheet	2 to 3 hours at 20°C	10 minutes at 105°C
Colour	Prod data sheet	yellow	
Fire resistance	Prod data sheet	combustible	
Solvant	Prod data sheet	White spirit	
Flash point	Prod data sheet	minimum +39°C	
Coverage range	Prod data sheet	0.40 kg/m² approx	
Storage	Prod data sheet	from 0 to + 45°C	shelf life: 2 years in original unopened container

NOTE: Pittsburgh Corning LTAA compound 2A or equivalent.

Appendix 2

Material specifications N°102

LOW TEMPERATURE ANTI-ABRASIVE COATING		Form: drum	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		one-component water based fire resistive coating	
Apparent density	ASTM D1475	1.6 kg/dm^3	
Solids (non-volatile)	ASTM D2369	69% by weight	(51% by volume)
Service temperature limits	Prod data sheet	- 196°C to + 93°C	
Application temperature	Prod data sheet	Between +4 to +38°C	
Drying	ASTM D1640	2 to 3 hours at 23°C	Set to touch: 45 to 90 minutes
Colour	Prod data sheet	Off white	
Fire resistance	ASTM E84	Flame Spread: 10 Smoke Developed: 10	Tested at 1.72 m²/l coverage rate
Storage	Prod data sheet	Between +4 to +38°C	Protect from freezing
Flash point	ASTM D93	over +100°C	
Coverage range	Prod data sheet	0.3 to 0.4 kg/m² approx	0.28 to 0.41 mm wet thickness

NOTE: FOSTER 30-16 WB or equivalent.

Appendix 2

Material specifications N°103

INSULATION REINFORCEMENT COATING		Form: factory applied on cellular glass	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		Two-component inorganic mortar and a glass cloth reinforcement, with styrolacylate, factory applied	
Apparent density	Prod data sheet	1.43 kg/dm^3	
Service temperature limits	Prod data sheet	- 196°C to + 320°C	
Compressive strength	Prod data sheet	> 10 N/mm²	
Tensile strength	Prod data sheet	> 0.5 N/mm²	
Modulus of elasticity	Prod data sheet	800 N/mm²	At ambient temperature
		1100 N/mm²	At - 120°C
Linear coefficient of thermal expansion	Prod data sheet	8 x 10^{-6} /K^{-1}	from + 20 to - 120°C
Water vapour diffusion resistance	Prod data sheet	Factor μ = ± 30	
Colour	Prod data sheet	Dark grey	
Fire resistance	Prod data sheet	non-flammable	incombustible

NOTE: Pittsburgh Corning PC 700 K or equivalent.

Appendix 2

Material specifications N°104

INSULATION JOINT SEALANT		Form: drum or cartridge	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		one-component, non hardening, butyl based sealer	
Apparent density	Prod data sheet	1.5 kg/dm^3	
Solids (non-volatile)	Prod data sheet	84% by volume	
Application temperature	Prod data sheet	+ 10 to + 25°C	
Drying	Prod data sheet	Non drying	skin in 1 to 3 hours
Colour	Prod data sheet	grey	
Permeability	Prod data sheet	0.01 perm	
Water vapour diffusion resistance	Prod data sheet	Factor μ = ± 23,000	
Fire resistance	Prod data sheet	dry: combustible	
Solvent	Prod data sheet	mineral oil solvents	
Flash point	Prod data sheet	minimum +40°C	
Coverage range	Prod data sheet	5.2 kg/m²	for 3 mm final layer
Storage	Prod data sheet	from 0 to + 45°C	shelf life: 2 years in original unopened container

NOTE: Depending on service temperature: Pittsburgh Corning PITTSEAL 444N, Foster FLEXTRA 95-50 or equivalent.

Appendix 2

Material specifications N°105

INSULATION BONDING ADHESIVE		Form: drum	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		two parts adhesive, modified bitumen based for component 1 and isocyanate for component 2	
Apparent density	Prod data sheet	1.05 kg/dm^3	
Mixing ratio, by weight	Prod data sheet	component 1: 42 parts Component 2: 1 part	
Service temperature limits	Prod data sheet	- 50°C to + 80°C	minimum - 40°C on stainless steel or aluminium maximum 120°C for low strength
Application temperature	Prod data sheet	+ 20 to + 35°C	Substrate: + 5 to + 35°C
Pot life	Prod data sheet	2 to 2h30	at 25°C ambient
Colour	Prod data sheet	black	
Permeability	Prod data sheet	0.01 perm cm	
Water vapour diffusion resistance	Prod data sheet	Factor μ = ± 23,000	
Fire resistance	Prod data sheet	dry: combustible	
Solvent	Prod data sheet	white spirit or chlorinated solvent	for tools cleaning
Flash point	Prod data sheet	minimum +40°C	
Coverage range	Prod data sheet	3 kg/m²	depend on substrate or application method
Storage	Prod data sheet	from 0 to + 45°C	maximum 2 1/2 years in original unopened container

NOTE: Pittsburgh Corning PC 88, Foster 81-84 adhesive sealant or equivalent.

Appendix 2

Material specifications N°107

COATING MASTIC		Form: drum	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		Tough, flexible and fire resistive elastomeric mastic containing DuPont Hypalon® rubber	
Apparent density	ASTM D1475	1.20 to 1.25 kg/dm^3	
Solids (non-volatile)	ASTM D1644	60% by weight	
Service temperature limits	Prod data sheet	- 46°C to + 104°C	
Application temperature	Prod data sheet	+ 4 to + 38°C	
Driyng time	ASTM D1640	Set to touch: 3 hours	Dry touch: 48 hours
Colour	Prod data sheet	White or Grey	
Permeability	ASTM F1249	0.03 perm	0.76 mm dry film
	ASTM E96	0.024 perm	1.3 mm dry film
Fire resistance	ASTM E84	Flame spread: 10	Smoke developed: 15
Flash point	ASTM D93	+ 43°C	
Wet coverage range	Prod data sheet	2 to 2.4 l/m²	for 2 mm (0.9 mm dry thickness), depend on substrate or application method
Storage	Prod data sheet	+ 4 to + 38°C	

NOTE: Foster 60-90/91 Monolar mastic, BS Coating HYPALKOTE 570 or equivalent.

Appendix 2

Material specifications N°108

ALUMINIUM-BUTYL MEMBRANE		Form: 50 to 1000 mm wide rolls	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		heavy duty, self vulcanising tape with aluminium/polyester laminate backing and a strong self bonding layer	
Construction		Compound of an elastomeric modified butyl rubber, pressure sensitive adhesive laminated with a 48 mic. thick Aluminium/Polyester (25 mic. Aluminium + 23 mic. Polyester) laminate foil and a silicone treated paper liner	
Apparent density	Prod data sheet	1.1 g/cm³	
Thickness	Prod data sheet	1.2 mm ± 3%	
Solids (non-volatile)	Prod data sheet	100%	
Service temperature limits	Prod data sheet	- 30°C to + 85°C	
Tack	Prod data sheet	immediatly	
Bonding time	Prod data sheet	24 hours max.	
Adhesion	Prod data sheet	2.0 kg/cm	on galvanised steel
Pressure rating	Prod data sheet	max. 4,000 Pa	measured at 20°C
Colour	Prod data sheet	Bright aluminium	
Permeability	Prod data sheet	0.00 Metric perm	for the complete product
		0.02 Metric perm	for the elastomeric butyl rubber
Flammability	DIN 4102	Class 1 B2 UL-listed	
Storage	Prod data sheet	dry	2 years in closed original packing

NOTE: IWR 701 AP, Temati TEMBUTIL IF or equivalent.

Appendix 2

Material specifications N°109

SELF ADHESIVE BANDS		Form: 12 to 75 mm wide x 50 m long rolls	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		glass reinforced filament tape mm10	
Construction		Rubber-resine adhesive with polypropylene backing biaxially oriented	
Total thickness	Prod data sheet	135 microns	
Backing thickness	Prod data sheet	32 microns	
Adhesion to steel	Prod data sheet	9.6 N/10 mm	
Tensile strength	Prod data sheet	250 N/10 mm	
Service temperature limits	Prod data sheet	- 35°C to + 130°C	
Elongation	Prod data sheet	8.5%	
Static shear	Prod data sheet	4500 minutes	
Colour	Prod data sheet	Transparent	
Storage			

NOTE: IWR Glass reinforced filament tape mm 10 or equivalent.

Appendix 2

Material specifications N°110

BUTYL RUBBER SHEET		Form: 1 mm thick x 1 m wide x 12 m long rolls	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		Polyisobutylene (PIB) sheeting for contraction joints	
Construction		High molecular weight polyisobutylene	
Total thickness	Prod data sheet	0.5 to 2 mm	
Chemical resistance	Prod data sheet	majority of chemicals	
Oil resistance	Prod data sheet	attacked by:	aromatic, aliphatic, hydrocarbon oils
Tensile strength	Prod data sheet	2.5 MN/mm²	
Service temperature limits	Prod data sheet	- 34°C to + 72°C	
Elongation	Prod data sheet	300%	
Vapour permeability	Prod data sheet	5.0 g/m/,001"/m²/day	at 38°C
Colour	Prod data sheet	black	
Welding agent	Prod data sheet	"B" type for tropical or "E" type for moderate climates	to seal overlapping seams by means of vulcanisation of butyl rubber sheet

NOTE: IWR Butyl rubber sheet or equivalent.

Appendix 2

Material specifications N°112

REINFORCING FABRIC for COATING MASTIC		Form: 1.0 m wide x 50 m long rolls	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		Fibreglass scrim fabric for coating mastic reinforcement	
Construction		**Fibreglass** coated with weavelock, 3.8 x 3.9 setting/cm	
Weave	Prod data sheet	Leno	
Visual mesh	Prod data sheet	10 x 10	openings per square inch
Thickness	Prod data sheet	0.20 mm	
Tensile strength	Prod data sheet	85 x 75 daN/5 cm	warp x weft
Weight	Prod data sheet	58 g/m²	
Service temperature limits	Prod data sheet	300°C	
Fire classification	Prod data sheet	M0	
Storage			

NOTE: FOSTER SCRIMTEX™ or equivalent.

REINFORCING FABRIC for COATING MASTIC		Form: 1.0 m wide x 45 m long rolls	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		Synthetic fabric for coating mastic reinforcement	
Construction		**Polyester** with 3.175 mm opening	
Visual mesh	Prod data sheet	6 x 6	openings per square inch
Thickness	Prod data sheet	0.70 mm	
Tensile strength	Prod data sheet	280 x 550 N	warp x weft
Weight	Prod data sheet	90 g/m²	
Service temperature limits	Prod data sheet	- 35 to + 80°C	
Fire classification	Prod data sheet	combustible	
Storage			

NOTE: Pittsburgh Corning PC 79 or equivalent.

Appendix 2

Material specifications N°113

HIGH TEMPERATURE JOINT SEALANT		Form: 310 ml cartridge	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		one-component silicone, elastomeric acetic sealant	
Apparent density	Prod data sheet	± 1.04 kg/dm^3	
Service temperature limits	Prod data sheet	- 60°C to + 260°C	315°C for intermittent exposure
Application temperature	Prod data sheet	- 5 to + 40°C	
Skin-over time	Prod data sheet	10 minutes	
Tack-free time	Prod data sheet	17 minutes	
Cure time	Prod data sheet	24 hours	3 mm thickness
Colour	Prod data sheet	red	
Elongation at break	ISO 8339	150%	
Tensile strength at break	ISO 8339	± 0.6 Mpa	
Flow / Slump	ISO 7390	< 2 mm	
Fire resistance	Prod data sheet		
Storage	Prod data sheet	from + 5 to + 25°C	12 months, in original unopened containers

NOTE: Den Braven Sealants TECSIL HT 300 RED, Dow Corning 736 or equivalent.

Appendix 2

Material specifications N°115

HIGH TEMPERATURE COLLARS FOR INSULATION TERMINATION		Form: Cylindrical collar in two halves assembled by 316L SS screws	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		High temperature Roving of fiber glass and epoxy resin laminate	
Construction		cylindrical collars in two halves fabricated from panels, 12 to 30 mm thick	
Density	Prod data sheet	1.980 kg/m³	
Colour	Prod data sheet	brown	
Service temperature limits	Prod data sheet	330°C	
Thermal conductivity	Prod data sheet	0.3 W/m.K	
Compressive strength	Prod data sheet	250 Mpa at 260°C	to 380 Mpa at 150°C
Modulus of elasticity	Prod data sheet	20,000 Mpa	
Humidity absorption	Prod data sheet	0.05%	
Chemical resistance	Prod data sheet	majority of chemicals	Excellent to water and oils
Storage			

NOTE: ELIT Roving verre epoxy HT330R or equivalent.

Appendix 2

Material specifications N°116

FLEXIBLE INSULATING MATTRESS		Form: Flexible enclosure for valves and flanged joints	
Properties	**Documents Reference**	**Min/max values**	**Remarks**
Product		Flexible insulating mattress, custom fabricated, using a quilted construction of mineral wool mattress positioned between two fiberglass cloth	
Construction	up to 260°C	Inner and outer faces: Fiberglass cloth, silicone coated (1) Insulating material: mineral wool mattress, 80 kg/m³ minimum, for technical datas, refer to material specification N°003	
	260 to 430°C	Inner face and sides: High temperature Fiberglass cloth (2) Outer face: Fiberglass, silicone coated (1) Insulating material: mineral wool mattress, 80 kg/m³ minimum, for technical datas, refer to material specification N°003	
(1) FIBERGLASS CLOTH, SILICONE COATED		**Form: 100% E-Glass fiber, 1500 mm wide**	
Weight	Prod data sheet	525 g/m² ± 30 g/m²	
Thickness	Prod data sheet	0.45 mm	
Weave	Prod data sheet	Satin	
Warp	Prod data sheet	19.2 ± 0.3	yarns/cm
Weft	Prod data sheet	11.1 ± 0.3	yarns/cm
Service temperature limits	Prod data sheet	280°C	
Fire classification	Prod data sheet	M1	
Treatment	Prod data sheet	High temperature Silicone coating	50 g/m² on each face

NOTE: ELIT Elitex VS 969-06 or equivalent.

(2) HIGH TEMPERATURE FIBERGLASS CLOTH		**Form: 100% Glass fiber, 1000 mm wide**	
Weight	Prod data sheet	640 g/m² ± 5%	
Thickness	Prod data sheet	0.85 mm	
Warp	Prod data sheet	6.8 ± 3%	yarns/cm
Weft	Prod data sheet	5.8 ± 3%	yarns/cm
Tensile strength	Prod data sheet	700 x 600 N/cm ± 10%	warp x weft
Service temperature limits	Prod data sheet	550°C	
Fire classification	Prod data sheet	M1	
Treatment	Prod data sheet	Thermal treatment	

NOTE: ELIT Elitex 656 F111 or equivalent.

(3) SECUREMENT		**Form:** VELCRO overlapping and/or straps/belts with SS 316L buckles
Product		Fiberglass cloth, silicone coated, as (1) above

Appendix 3 Principle sketches

N°201: Hot insulation - operating temperature up to 135°C - insulation termination

N°202: Hot insulation - operating temperature up to 135°C - pipe support

N°203: Hot insulation - operating temperature 136 to 260°C - insulation termination

N°204: Hot insulation - operating temperature over 135°C - pipe support

N°205: Hot insulation - operating temperature over 260°C - insulation termination

N°206: Hot insulation - operating temperature 136 to 330°C - insulation termination - alternate

N°207: Hot insulation - expansion joint

N°208: Hot insulation - operating temperature up to 135°C - equipment details

N°209: Hot insulation - operating temperature 136 to 260°C - equipment details

N°210: Hot insulation - GRP cladding - pre-cured pipe sections and moulded pieces

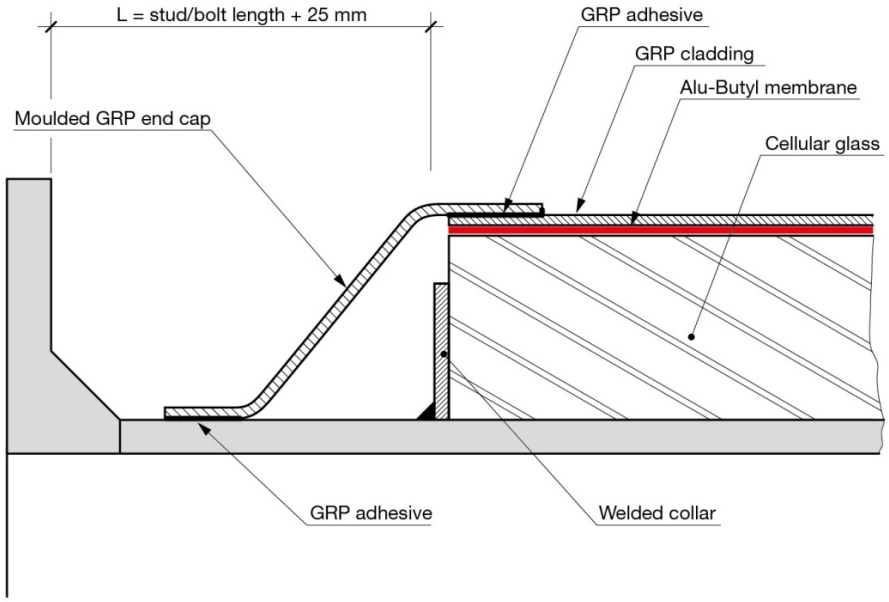
N°211: Hot insulation - tee, branches, nozzles

N°212: Hot insulation - GRP cladding reinforcement - vessel and equipment Ø ≥ 1200 mm

Appendix 3

Principle sketch N°201

Hot insulation
Operating temperature up to 135°C
Insulation termination



General Specification	GS EP COR 771
Thermal insulation (hot and dual services)	

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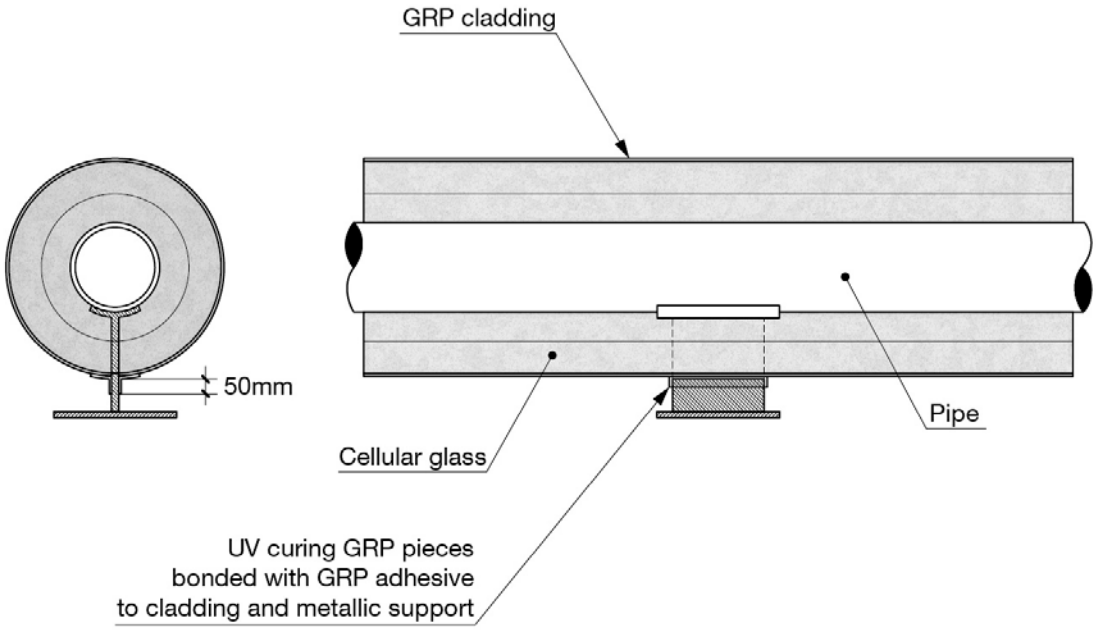
Appendix 3

Principle sketch N°202

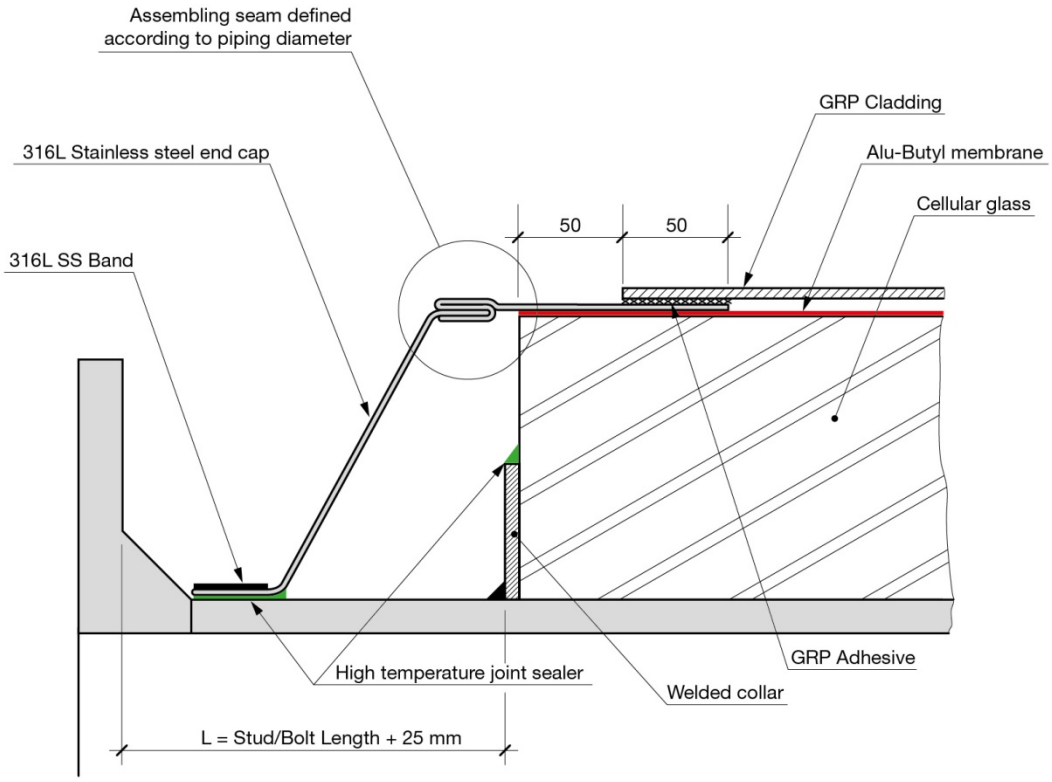
Hot insulation
Operating temperature up to 135°C
Pipe support



Appendix 3

Principle sketch N°203

Hot insulation
Operating temperature 136 up to 260°C
Insulation termination

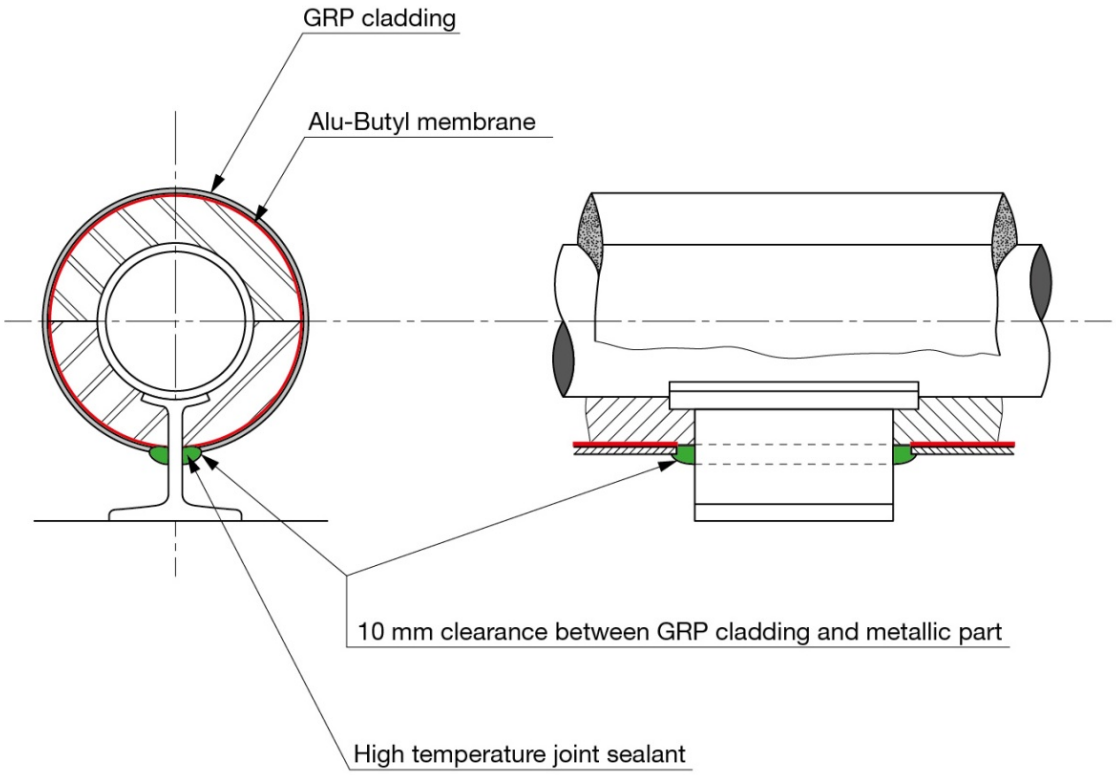


Note: Webbing tape shall be used between pipe and stainless steel end cap when valve or flanged joints are insulated (refer to principle sketch N°205).

Appendix 3

Principle sketch N°204

Hot insulation
Operating temperature over 135°C
Pipe support



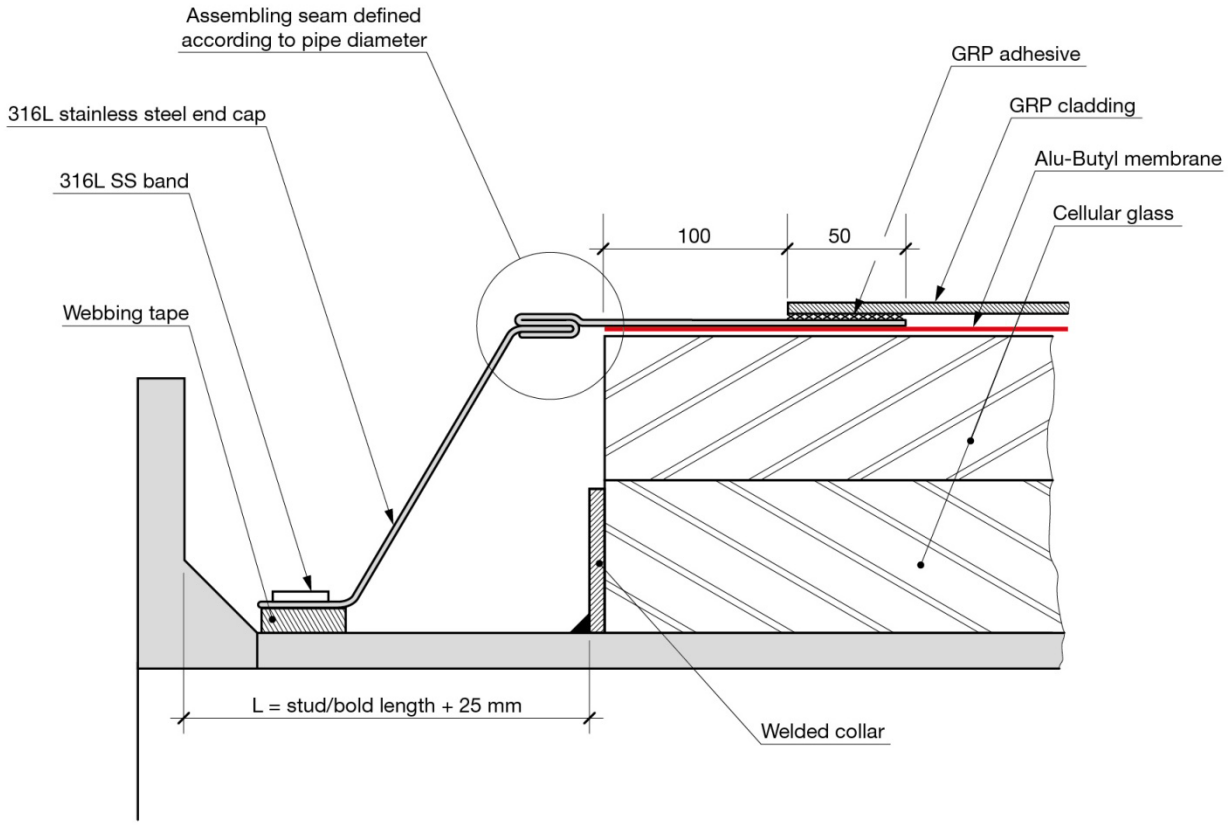
Note: For operating temperature over 260°C **do not apply joint sealant.**

General Specification	GS EP COR 771
Thermal insulation (hot and dual services)	

Appendix 3

Principle sketch N°205

Hot insulation
Operating temperature over 260°C
Insulation termination

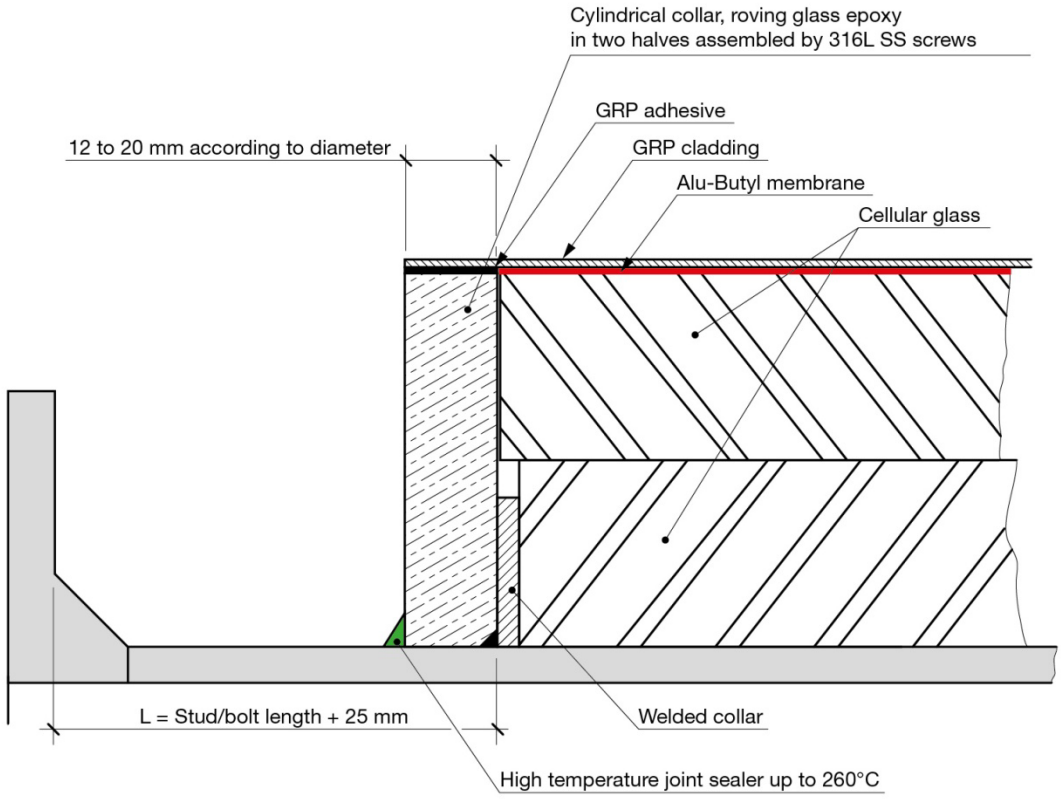


General Specification	GS EP COR 771
Thermal insulation (hot and dual services)	

Appendix 3

Principle sketch N°206

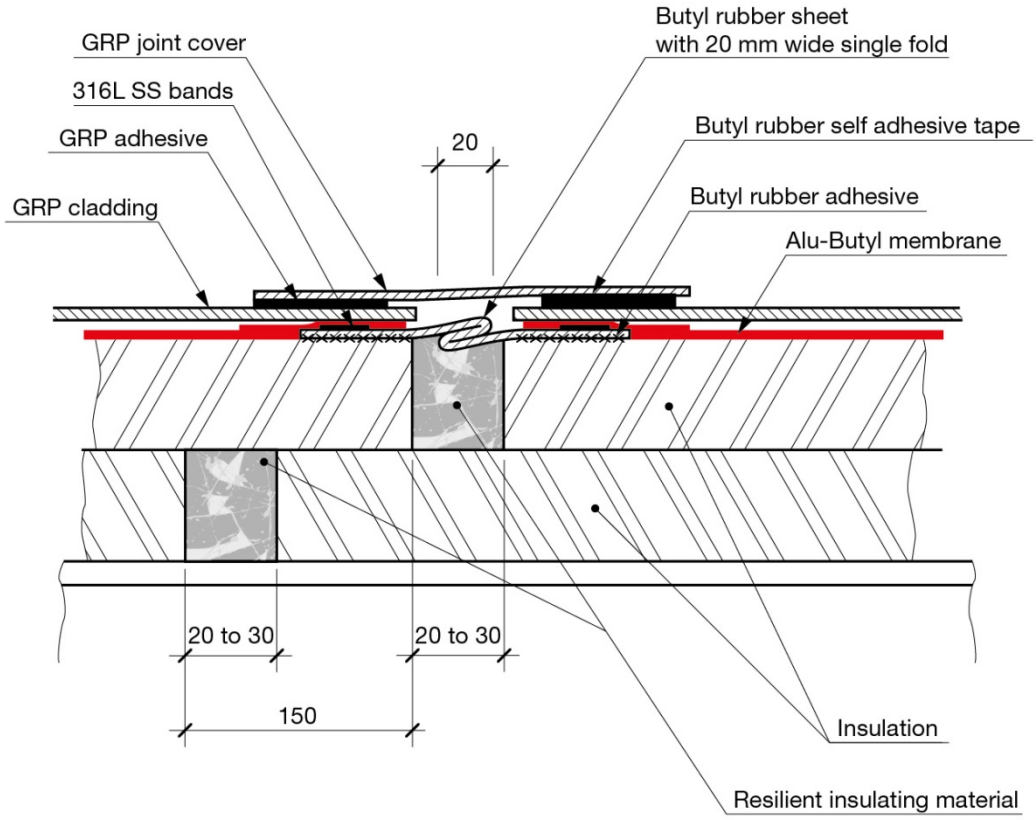
Hot insulation
Operating temperature 136 up to 330°C
Insulation termination
ALTERNATE



Appendix 3

Principle sketch N°207

Hot insulation
Expansion joint



Note: GRP contraction joints shall be prepared and installed in accordance with manufacturer instructions.

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Thermal insulation (hot and dual services)	

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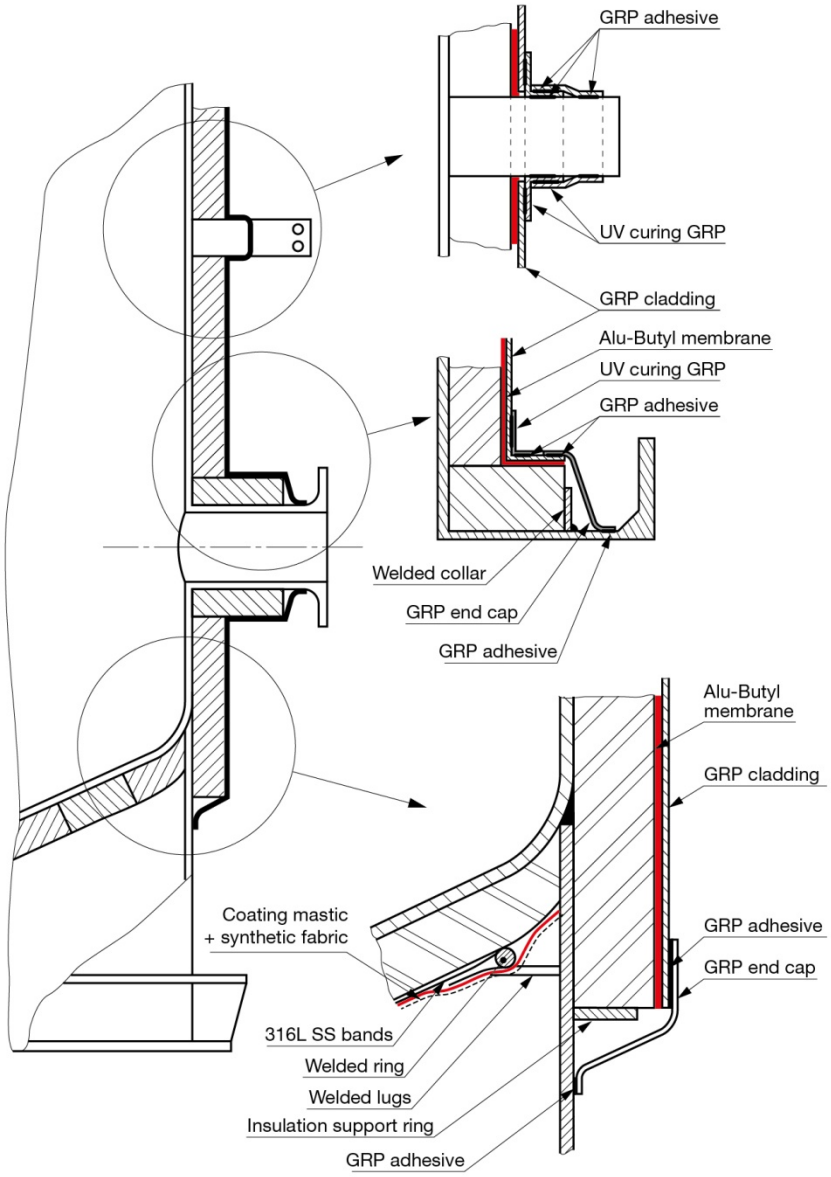
Appendix 3

Principle sketch N°208

Hot insulation
Operating temperature up to 135°C
Equipment details

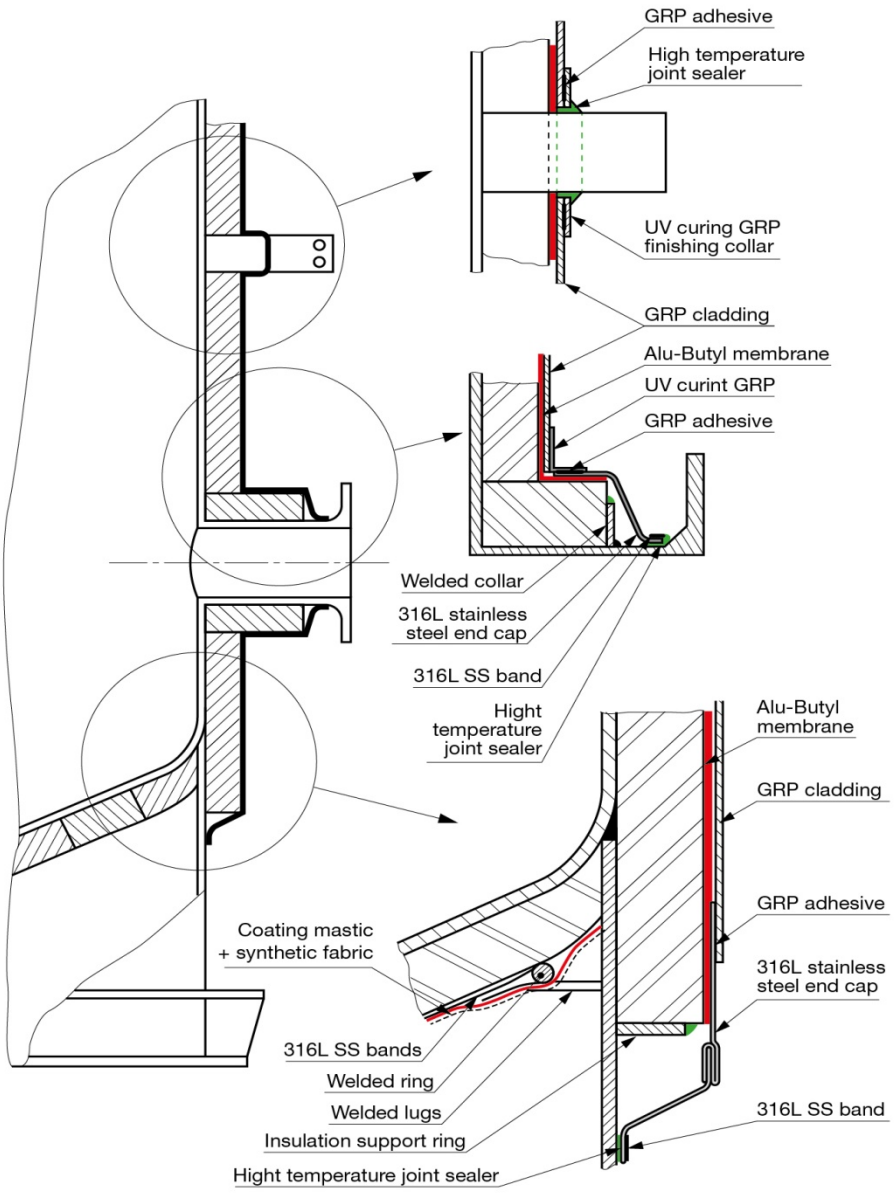


General Specification	GS EP COR 771
Thermal insulation (hot and dual services)	

Appendix 3

Principle sketch N°209

Hot insulation
Operating temperature 136 up to 260°C
Equipment details



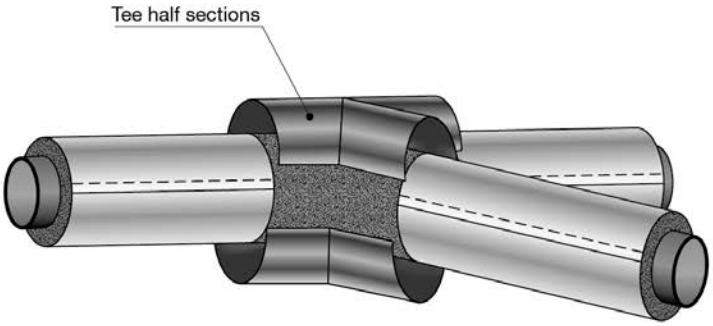
Note: For operating temperature over 260°C **do not apply joint sealant.**
Refer to "hot insulation - Insulation termination" for details.

General Specification	GS EP COR 771
Thermal insulation (hot and dual services)	

Appendix 3

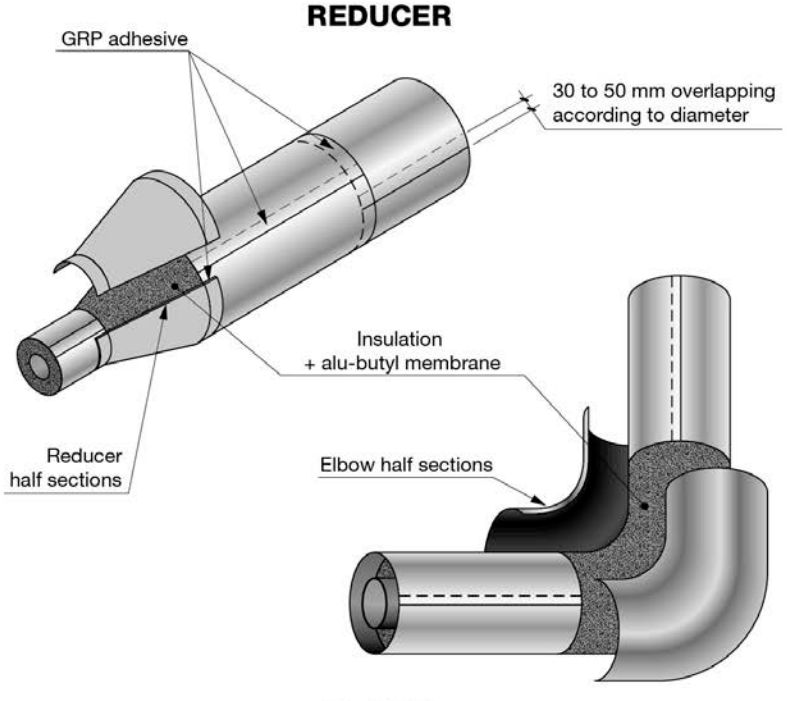
Principle sketch N° 210

Hot insulation
GRP cladding
Pre-cured pipe sections and moulded pieces



TEE

REDUCER



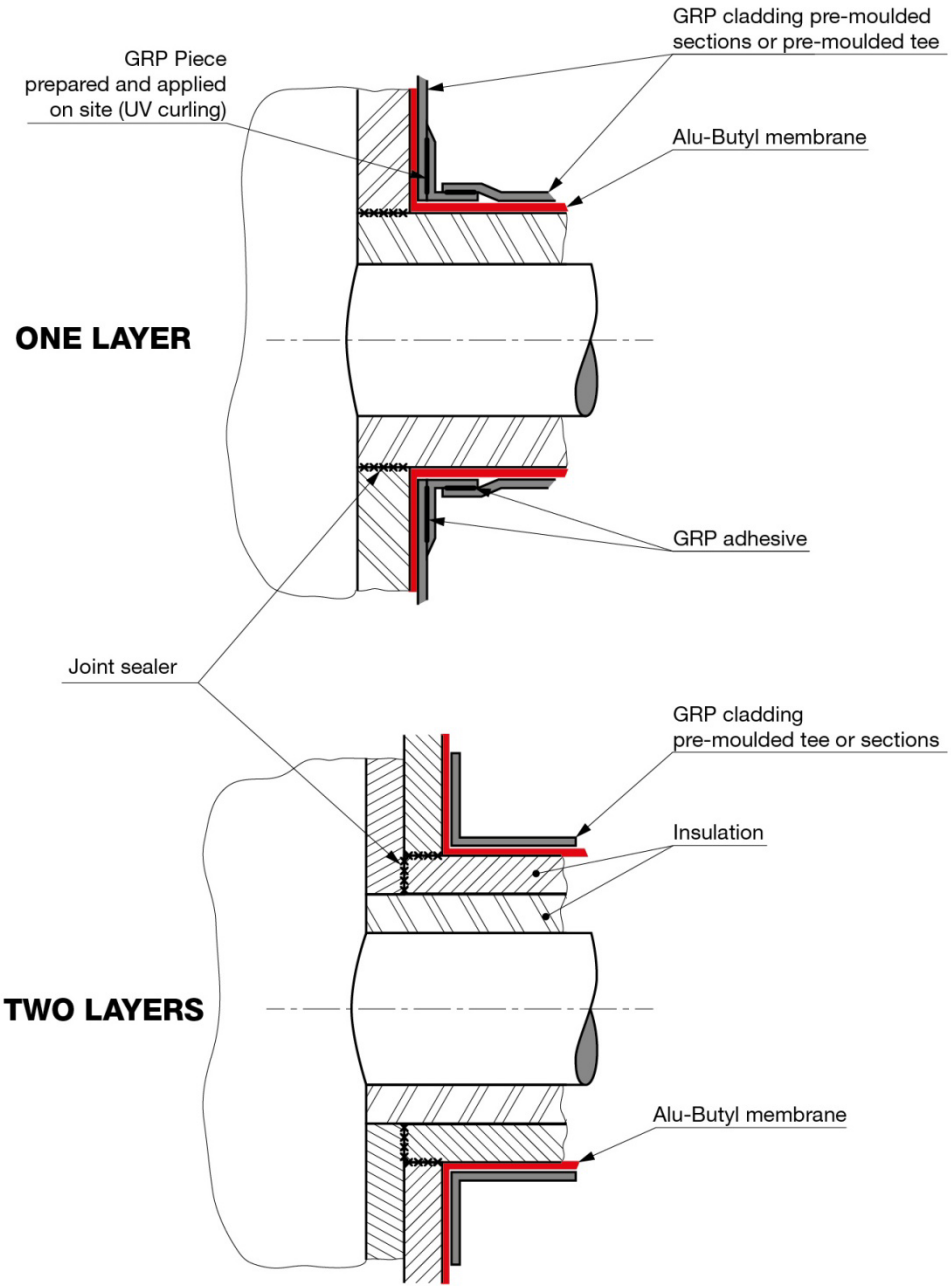
ELBOW

Appendix 3

Principle sketch N°211

Hot insulation

Tees, branches, nozzles



Note: GRP cladding pre-moulded tee or pre-moulded sections + GRP piece prepared and applied on site may be used as well for one layer than two layers insulation application.

General Specification	GS EP COR 771
Thermal insulation (hot and dual services)	

Appendix 3

Principle sketch N° 212

Hot insulation
GRP Cladding reinforcement
Vessel and equipment ø ≥ 1200 mm